A MODEL TO DIAGNOSE LEARNING OBSTACLES AND TO FACILITATE THE ADOPTION OF THE SI METRIC SYSTEM WITHIN ORGANIZATIONS

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THESIS

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SI METRIC SYSTEM WITHIN ORGANIZATIONS

by

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I. INTRODUCTION

"From the early days of the Republic, the United States has repeatedly considered the question of going metric. Yet today, on the eve of the nation's second centennial, the question remains unsettled."

The above paragraph, quoted from a report to the Congress by the U.S. Metric Study [1], depicted well the history and present situation of the U.S. concerning the adoption of the metric system.

Indeed, during the last two centuries, many propositions and recommendations for the standardization of measurement have been presented to the Congress, especially those of:

- Thomas Jefferson in 1790
- John Quincy Adams in 1821
- Joseph Henry in 1865
- John A. Kasson in 1866.

The Congress considered them with much debate, but each time action was postponed. The only significant action was the enactment of three metric bills [2], in response to the Kasson Committee report in 1866. The most important (Metric System Act, PL 14:339, July 28, 1866) legalized the use of metric weights and measures. One of the others (PL 14:301, July 27, 1866) directed the Postmaster General to distribute metric postal scales to all post offices exchanging mail with foreign countries. The other (PL 14:369, July 27, 1866),

directed the Secretary of the Treasury to furnish each State with one set of metric standards.

Although these acts constituted a considerable step toward the use of metric system, they did not establish a national policy to promote the predominant use of this measurement system. There were many reasons for the delay in going metric. The main obstacle seemed that the metric system was not then in use by the major trading partners of the U.S.

In the last 20 years the metric system has become the dominant language of measurement in the world. Only a few nations (13 out of over 140 countries, or less than 10%) have not yet adopted the metric system or decided to do so. Of these, the U.S. is the only technologically advanced country. Even Great Britain, where the customary system of measurement originated, has almost completed her "metrication" program this year. So the main obstacle mentioned in the above paragraph has been removed. Moreover, the use of the metric system has increased noticeably in many sectors of the United States, especially education and pharmacy.

Probably motivated by this marked metric trend, the Congress, through the Metric Study Act (PL 90-472, August 9, 1968), directed the Secretary of Commerce to undertake the U.S. Metric Study. Its purpose was "to determine the impact of increasing worldwide use of the metric system on the U.S.; to appraise the desirability and practicability

of increasing the use of metric weights and measures in the U.S.; to study the feasibility of retaining and promoting by international use of dimensional and other engineering standards based on the customary measurement units of the United States; and to evaluate the costs and benefits of alternative course of action which may be feasible for the U.S." [3].

The Study should be completed within three years during which interim reports and a full and complete final report of the findings, with appropriate recommendations, should be submitted to the Congress.

The Study was planned to give every sector of society an opportunity to express its views with respect to the questions raised by the Metric Study Act. The plan provided for a series of seven public hearings, called National Metric Study Conferences, supplemented by eleven special investigations.

The public hearings included representatives associated with manufacturing and nonmanufacturing industries, organized labor, small businesses, engineering and scientific disciplines, education at all levels, advertising, publishing, law, medicine, public health, agriculture, forestry, fisheries, agencies of Federal, state, county, and local government, real estate, college athletics, finance, insurance, warehousing, transportation, construction, communications, retailers, wholesalers, chiefs of police, fraternal organizations, exporters and importers, home economists, consumers, and

other groups that could be affected by a change in the nation's system of measurement.

The investigations that supplemented the hearings covered the following subjects:

(1) Manufacturing Industry

(2) Nonmanufacturing Businesses

(3) Education

(4) Consumers

(5) International Trade

(6) Engineering Standards

(7) International Standards

(8) Department of Defense

(9) Federal Civilian Agencies

(10) Commercial Weights and Measures

(11) History of the Metric System Controversy in the U.S.

Each of these investigations is the subject of a volume, published as part of the record of the U.S. Metric Study [4 to 14]. The public hearings are summarized and analyzed in an additional volume [15]. The final report was published in July 1971 under the title "A Metric America: A Decision Whose Time has Come" [1]. Experiences in metric changeover from other countries — especially Japan and Great Britain — have also been considered and summarized in the final report [Ref. 1, Chapter X].

During the Study, many courses of action were conceived, including an abrupt and mandatory conversion to metric and a

program to promote more use of the customary system in the world. However, the feasible courses of action were narrowed to two main alternatives:

Course One: The United States follows no overall plan. Each firm or other entity pursues its own measurement policy. A target date for the nation to become predominantly metric is not set. The government does nothing to impede or foster the change.

Course Two: The nation goes metric according to plan, under an overall national program with target date for becoming predominantly metric. Within this framework, segments of the society work out their own specific timetables and programs, dovetailing them with the programs of other segments.

The analysis of the final report focused on these alternative courses of action and came up with the following recommendations:

(1) The U.S. change to the International Metric System through a coordinated national program over a period of ten years, at the end of which the nation will be predominantly (but not exclusively) metric.

(2) Within the broad framework of the national program, each segment of society should work out its own specific timetables and programs, dovetailing them with those of other segments.

(3) The Congress assign a central coordinating body. This coordinating body would work with all groups in the

society that were formulating their own plans, so as to ensure that their plans meshed. It would help to decide how the public could be best familiarized with the metric system. It would advise government agencies of changes in codes and regulations that would require attention. And it would have to anticipate and deal with other special problems.

(4) Groups of industries would coordinate their efforts with the help of trade associations and agencies of Federal, state, and local governments.

(5) Two areas merited immediate attention, even if a national program was not adopted: education and international standards.

Almost all participants in the U.S. Metric Study stressed the importance of education in any change to metric. Citizens need to be informed of what the change would mean in their jobs and everyday lives. Metric measurement needs to be taught more vigorously in the schools.

The Study strongly recommended that the U.S. begin to participate more intensively in the making of international standards which would increasingly influence world trade.

(6) The costs of going metric should be borne in such a way as to minimize the overall cost to the nation and to avoid bureaucratic waste. The experience of the British "to let the costs lie where they fall", which was also followed by the Japanese, would be adopted by the United States.

Four years have elapsed since the submission of the U.S. Metric Study report and yet no significant and effective action has been taken by the Congress. In 1973, a bill (S-100) was introduced by two senators to the Committee on Commerce of the Senate. Its purpose was "to provide a national program in order to make the international metric system the predominant but not exclusive system of measurement in the U.S. and to provide for converting to the general use of such system within ten years" [16]. To date, this "Metric Conversion Act" has not been approved by Congress.

Most sectors of society had not started the metric changeover in 1971. Those which had started, continued it often without coordination, even within an organization. For example, in some schools, while the departments of mathematics and sciences had been teaching completely in metric for years, the shop classes still used the Customary system exclusively.

As revealed by the U.S. Metric Study, going metric was not a question of "whether", but of "when" and "how" (i.e. with or without a national program). Delay in the changeover would not stop the metric trend but would make it more costly to the society as well as to each organization [Ref. 1, Chap. IX]. Therefore, it would be better for each organization to complete the conversion as soon as possible. In cases where the conversion program needed to be dovetailed with those of other organizations, the organization should be prepared for a coordinated changeover. In any case, every

organization needs early preparation which consists essentially of planning and training. Experience in Great Britain, in Japan, and in some segments of the U.S. showed that careful planning and adequate training would provide the key to a fast and economical success in metric changeover. This might be the reason why almost all participants in the U.S. Metric Study stressed the importance of education in the change to metric as mentioned above.

Aiming to develop a model to increase adoption of metric system within organizations, this student effort emphasized the learning and innovation aspects of the problem. Surveys were conducted through questionnaires, and interviews at three schools and one business. The three schools covered almost all levels of education. The firm was of medium size.

Data from the surveys were analyzed and interpreted in the light of recent theories on learning, innovation, and technology transfer. The model was formulated through the use of some matrices. It was also intended to be used -- with some modification - whenever a new method or "language" was to be adopted by an organization.

II. REVIEW OF THE LITERATURE

As indicated in the title — a model to diagnose learning obstacles and to facilitate the adoption of the metric system within organizations — this study is essentially related to three subjects: the metric system itself, the theory on innovation, and learning theory. Literature covering each subject is reviewed in the following sections. However, the application of theories on learning and innovation to the adoption of metric system within organizations has not been previously researched.

A. THE METRIC SYSTEM (SI)

As mentioned in the Introduction, most information about the metric system and its adoption in the U.S. can be found in the interim and final reports submitted to Congress by the U.S. Metric Study [Ref. 1, Refs. 4 to 15]. Many books on the subject were published in the last five years, particularly: Prepare Now for a Metric Future by F.R. Donovan, 1970 [17], Thinking Metric by Thomas F. and Marilyn B. Gilbert, 1973 [18], and Metric System Simplified by Gerard W. Kelly, 1974 [19].

1. History of the Metric System

In 1790, one year after the French Revolution, the French Academy of Sciences constructed a system, based on the most scientific principles of the time, which was wholly

rational, quite simple and internally consistent. Its keystone was the "meter", a unit of length defined as a specific fraction of the earth's circumference.

With provisional standards fabricated by 1795, laws had been passed in France to make the system compulsory. In 1799 an international conference was held in Paris to inform other nations about the metric system.

The system was not an unqualified success at first, even in France. Only after a hiatus of 25 years was it officially restored. Since 1840, when its use became compulsory, the metric system began to spread internationally at a rapid pace. By 1900 about 40 nations had adopted it.

To date, more than 90 percent of the countries in the world had adopted the metric system or committed to conversion.

In the U.S., the expansion of the metric system had encountered more difficulties. In 1875, however, the U.S. signed the Treaty of the Meter and, in 1893, became an <u>officially</u> metric nation as the new metric standards (received in 1889) were declared to be the nation's "fundamental standards".

Since its creation, the metric system has been streamlined and became an international measurement system, known as SI (Système International d'Unités).[1]

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[1]Unless otherwise stated, the term "Metric System" used in the remainder of this study refers to SI.

2. What is the Metric System (SI)?

There are six base-units in the Metric System (Table 2-1).

Table 2-1 Base-Units of the I.M.S.

Base-Quantities	Base-Units	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Celcius or Kelvin	C K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd

All other units of measurement in the International Metric System are derived from these six base-units. These units are described more fully in Appendix A.

The metric system is based on the decimal system. Multiples and submultiples of any given unit are always related by powers of 10. For instance, there are 10 millimeters in one centimeter; 100 centimeters in one meter. This greatly simplifies converting larger to smaller units and vice-versa. The conversion is done through multiplication or division by 10, or a multiple of 10, or simply by moving the decimal point one or more places to the left (converting smaller to larger units) or to the right (larger to smaller units).

For example, 5.841 kilometers is converted to meters by multiplying by 1,000 (moving the decimal point three places to the right) and the answer is 5,841 meters.

Multiples and submultiples of all the International Metric units follow a consistent naming scheme, which consists of attaching a prefix to the unit, whatever it might be. For example, kilo stands for 1,000; one kilogram equals 1,000 grams. Centi is the prefix for one hundredth; one meter equals 100 centimeters. Table 2-2 gives some commonly used prefixes, their symbols and meanings (for other prefixes, see Appendix A).

Table 2-2 Names and Symbols for Metric Prefixes

Prefix	Symbol	Meaning	Multiplication Factor
Mega	M	One million times	10^6
Kilo	K	One thousand times	10^3
Hecto	h	One hundred times	10^2
Deca	da	Ten times	10
Deci	d	One tenth of	10^{-1}
Centi	c	One hundredth of	10^{-2}
Milli	m	One thousandth of	10^{-3}
Micro	μ	One millionth of	10^{-6}

In all, the International Metric System can be considered as the most coherent, rational, consistent and simple system of measurement. It was designed deliberately to fill all of the needs of scientists and engineers, although laymen need only know and use a few simple parts of it. It is logically streamlined, whereas other systems developed more or less haphazardly.

3. Metric Beachheads

In the U.S. society, the metric system is slowly advancing under its own power, although sporadically and in piecemeal fashion. These changes seemed to have taken place in activities and disciplines which were more or less self contained.

Pharmacists and physicians have converted to metric with no serious problems. With few exceptions, the language and tools of U.S. science are entirely metric. In math and science education, throughout most of the country the metric system is taught to a large extent, even to very young children. The U.S. Army uses metric units in its maps for distance and elevation, the U.S. Navy is familiar with 20 millimeter and 40 millimeter guns. The National Aeronautics and Space Administration has gone metric since 1970.

The metric system also finds its use in automobile industry (manufacturing, repair), sports (swimming pools, skis), photography (film size, lens characteristics), food industry (net weight marked on food cans).

These examples, though far from exhaustive, do indicate that metric measurements and practices have established many beachheads in the U.S.

4. Arguments for Metric and for Customary Systems

In the course of almost two centuries of the U.S. history, perhaps the longest running debate is whether the U.S. should adopt the metric system. Dozens of arguments have been advanced, attacked, and defended with passion and excitement.

Not a few of the common arguments are demonstrably false, even a bit frivolous. Serious arguments, however, have been advanced by both pro-metric and pro-customary spokesmen. The most important ones are as follows.

a. Pro-customary Arguments

(1) Customary units of length (foot, yard, ...) are closely related to everyday experience and to some segment of the human body.

(2) The customary system doesn't use a decimal base, but both its duodecimal (base 12) and binary (base 2) bases are handier. The duodecimal has more factors (2,3, 4,6) than the decimal (2,5), and multiplying or dividing by 2 is quite simple. In the age of computers, the machine can handle any unit.

(3) Changing to metric would cause confusion and waste of money and time. Double documentation and tooling inventories, retraining of people, safety hazards due to mistakes, study and planning for the conversion, ... would

constitute a huge expenditure for bit firms and almost insurmountable obstacles for small businesses.

(4) Going metric would open the way to import from countries that do not now make products to customary specifications, hence causing more competition for domestic industries.

The U.S. export trade (estimated at $20 billion for measurement-sensitive products in 1975) is so small compared with the Gross National Product (estimated at $1,500 billion in 1975) that the advantage of manufacturing according to metric standards would be insignificant and can hardly compensate the cost of changing over.

(5) Deciding to go metric when the U.S. economy is still in a recession is likely to bring out the reaction that this is the wrong time. The conversion might complicate all the economic problems.

b. Pro-metric Arguments

(1) From antiquity people have learned to count on their 10 fingers. Today the decimal numbering system is being used by almost all mankind, including the people of the U.S. No arithmetic operations could be simpler than moving a decimal point.

(2) The use of only one main unit (meter, gram or square meter, ...) in each kind of quantity (length, weight, area, ...) and the attachment of the same set of prefixes (kilo, hecto, centi, ...) to form multiples and

sub-multiples make the metric system the most coherent and easy to remember as for unit names.

(3) Experience in Great Britain and even in the U.S. showed that the metric conversion turned out to be much easier and less costly than anticipated.

In England, a great many of the expected difficulties were in the main amenable to simple solutions. More details on cost of conversion shall be discussed later in this section. During adjustment to the new measurements there might be a change to eliminate many of the superfluous varieties of materials, thus reducing inventories and offering an opportunity to improve engineering standards.

(4) Once the conversion is completed, the metric system, with its unequaled simplicity as pointed out in (1) and (2) above, is easier to learn and to use. Schools would have extra time to teach some of the new subjects now being introduced into the curricula. Engineers, technicians, and workers would save time and make fewer errors.

(5) Though small in relation to the total economy, the U.S. exports are crucial to maintaining a favorable trade balance in an increasingly metric world. The U.S. economy today, as never before, depends on trading raw materials, manufactured products, even technological ideas with countries that have changed to metric.

(6) The U.S. has made its first steps toward the metric system, although slowly and in an unorganized way. It will never cost less than it will right now. The longer the change without plan and coordination, the higher the cost. The costs of metric conversion would be temporary, the benefits would continue indefinitely.

5. Engineering Standards

Broadly speaking, engineering standards are agreements that specify characteristics of things or ways to do things — almost anything that can be measured or described. They cover an enormous range: e.g. the diameter of wire, the length and width of typewriter paper, the way to test for sulphur in fuel oil, ...

Taken together, engineering standards serve as both a dictionary and a recipe book for a technical society. Mass production would not be feasible if engineering standards were not established.

Engineering standards are developed by many organizations or groups at different levels; a single firm, a national group or an international group.

The leading international groups are the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), in which all major nations, including the U.S., are represented.

Increasingly, countries are adopting IEC and ISO recommendations instead of first developing their own national

standards. The official measurement language of both IEC and ISO is the International Metric System (SI).

6. International Standards and Foreign Trade

In international relations, the difficulty was not so much that the U.S. talked a measurement language different from that of other countries. Rather, it was that many of the U.S. engineering standards, based on customary units, were incompatible with the standards used elsewhere. And this hampered the export of some U.S. products.

a. International Standards

As mentioned earlier, the U.S. is represented in the ISO and IEC. It would be economically beneficial for the U.S. to play a more vigorous role in the making of international standards.

In the give and take of international standards making, compromises tend to result in all parties giving a little ground and thus sharing in the cost of changes. Therefore, if the U.S. fully participates in the making of the great majority (90% in 1971) of international standards that remain to be developed, it would not be the only country that would have to adjust its national standards.

b. Foreign Trade

In world trade, standards are important mainly in "measurement-sensitive" products, i.e. products in which dimensions are critical. In 1969, the U.S. exported about $14 billion worth of measurement-sensitive products and

imported about $6 billion worth. The difference, $8 billion, was considerably more than the nation's favorable balance of trade in 1969, which was only $1.3 billion.

Standards based agreements could be a non-tariff barrier against the U.S. exports. And a relatively slight drop in the exports of measurement-sensitive products could mean the difference between a favorable and unfavorable U.S. trade balance.

According to the exporters asked by the U.S. Metric Study, if the U.S. had gone metric by 1970, the 1975 exports would have increased by about $600 million [Ref. 1, P. 61-64].

Besides exports and imports, another factor that is tending to integrate the world economy is the rise of giant multinational corporations, many of them either partly or entirely owned by U.S. companies. The total annual output by multinational firms in 1970 was reported at about $450 billion, almost half of the U.S. gross national product. U.S. business abroad accounts for roughly half of this $450 billion output. This huge but almost invisible segment of American industry is already going metric.

7. Opinions and Attitudes Toward the Change to SI Metric.

As was noted in the Introduction, the U.S. Metric Study was planned to give every sector of society an opportunity to express its opinions and views with respect to the questions raised by the Metric Study Act.

The U.S. Metric Study adopted several different approaches with the hope of letting each sector of society express itself on its own terms and on its own level of sophistication. Included in these approaches were three fundamental questions:

- Is increased metric usage in the best interests of the U.S.?
- If so, should there be coordinated national programs to change to metric?
- Over how many years should the change be made?

a. Manufacturing Industry

Almost 4000 companies were chosen to be a representative sample of some 300,000 U.S. firms that manufacture products.

Sentiment for or against going metric varied greatly even within the same kind of industry. <u>Large firms tended to be more in favor than small ones</u>.

As to whether a unilateral increase in metric use for their products would be desirable (irrespective of what the nation may decide), manufacturers were about evenly divided. But as to whether increasing the use of metric would be good for the country as a whole, an overwhelming majority voted "Yes". About 70 percent of those answering this question (representing 80% of the total employment) said that more use of metric would be in the best interests of the U.S. Figure 2-1 gives a picture of manufacturers attitude

Manufacturers Attitude Toward More Metric In the United States as a Whole

(Weighted by Size of Company)

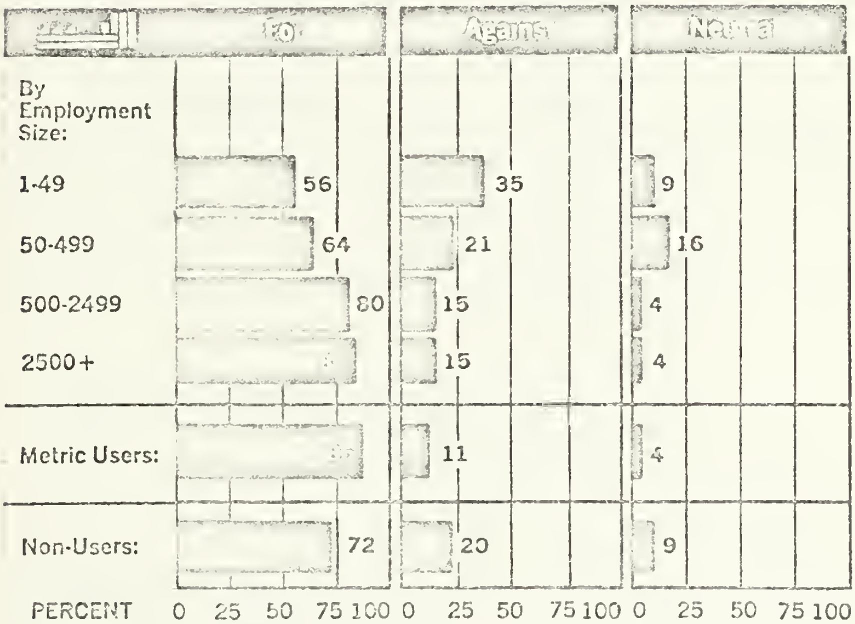


Fig. 2-1

Source: Reference 1, Page 73.

toward more metric in the U.S. as a whole (weighted by size of company).

As to what course of action should be followed in increasing metric use, more than 90 percent of those who responded preferred a coordinated national program, based on either voluntary participation or mandatory legislation. Only seven percent favored no national program for going metric. Table 2-3 gives the breakdown in percentages.

Table 2-3: If Increased Metric Usage is in the "best interests of the U.S.", what is the best Course of Action?

Coordinated National Program		93%
- voluntary	50%	
- mandatory	43%	
No Program		7%

b. Non-Manufacturing Businesses

The companies in this sector are engaged in such a variety of activities that gross figures of metric usage would mean little. Nevertheless, some general conclusions about attitudes can be drawn.

Sixty-one percent said that increasing the use of the metric system is in the nation's best interest (Figure 2-2).

Eighty-six percent of the non-manufacturing businesses were in favor of a national conversion program (Table 2-4).

The percentage of those responding who preferred a national program (86%) is less than that of the sampled manufacturing businesses (93%) but the percentage of those who preferred a mandatory national program (62%) is much higher than that of the manufacturing businesses (43%).

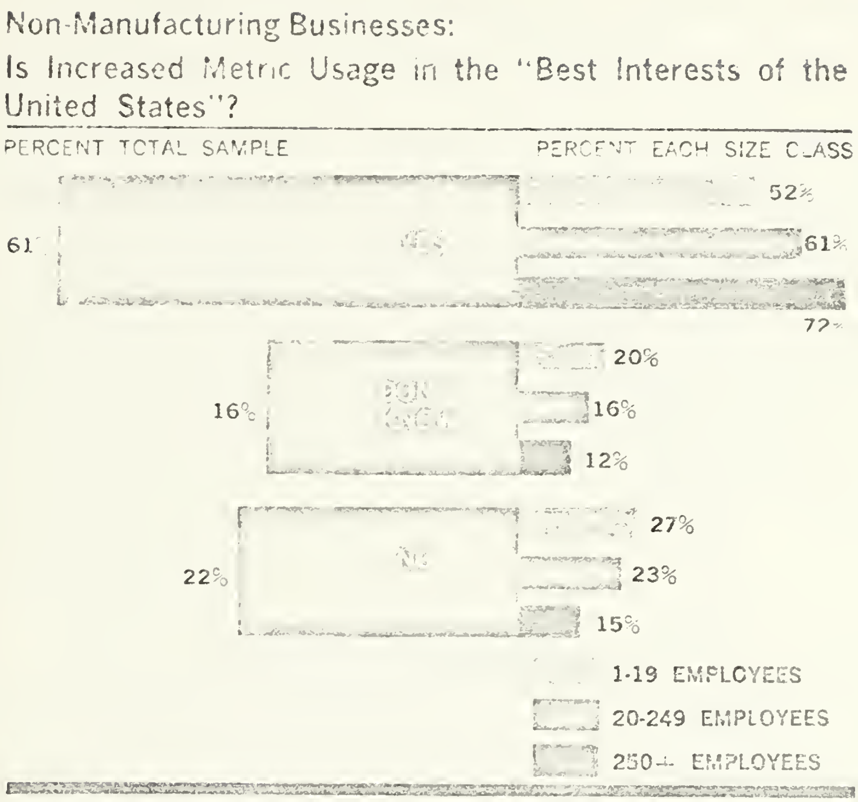


Fig. 2-2

Source: Ref. 1, Page 76

Table 2-4: If Increase Metric Usage is in the "best interests of the U.S.", What is the best Course of Action?

National Program		86%
- voluntary	24%	
- mandatory	62%	
No Program		8%
Don't Know, or No Answer		6%

c. Education

A public hearing devoted to education was attended by representatives of all leading teacher and school administration societies as well as many firms in the educational field. They represented a total of 1,600,000 people.

Educators are nearly unanimous in their endorsement of the metric system. Virtually all the individuals in the educational system and the firms associated with it make some use of the metric system and are in favor of a planned conversion program.

d. Government

The Department of Defense expresses no view as to whether increasing use of the metric system is in the best interests of the U.S. Nevertheless it stated that the armed forces could make a change over to metric without impairing their functions, assuming that industry would first convert through a coordinated national program.

As to whether conversion would be in the best interests of the military, the Defense Department found that "the compatibility of U.S. and foreign equipment will enhance combined military operations and simplify logistic support requirements" [Ref. 1, P. 78].

The view of 55 other Federal Government agencies roughly paralleled those of the manufacturing industry survey. More than half the agencies make some use of metric. Forty of the 55 agencies estimated that long-term advantages

of going metric would outweigh disadvantages, and almost all of these favored a coordinated national conversion program (Table 2-5).

Table 2-5: Views of 55 Federal Civilian Agencies

	YES	NO	DON'T KNOW
Favor Coordinated National Program	65%	7%	28%
Advantages Would Outweigh Disadvantages	60%	14%	26%

e. Public Attitudes and Knowledge of Metric

A sample of 1,400 families representative of 62 million family units in the U.S. were interviewed by the Survey Research Center of the University of Michigan.

As indicated in Figure 2-3, the survey revealed that:

(1) The general public knows little about the metric system.

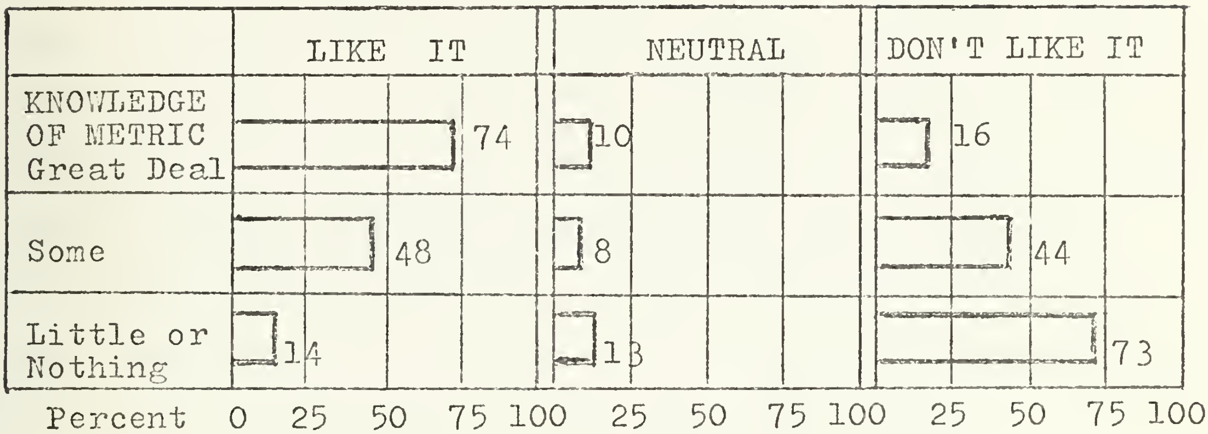
(2) People under 25 know more about the metric system than older people.

(3) The degree of knowledge of the metric system increases with the level of education.

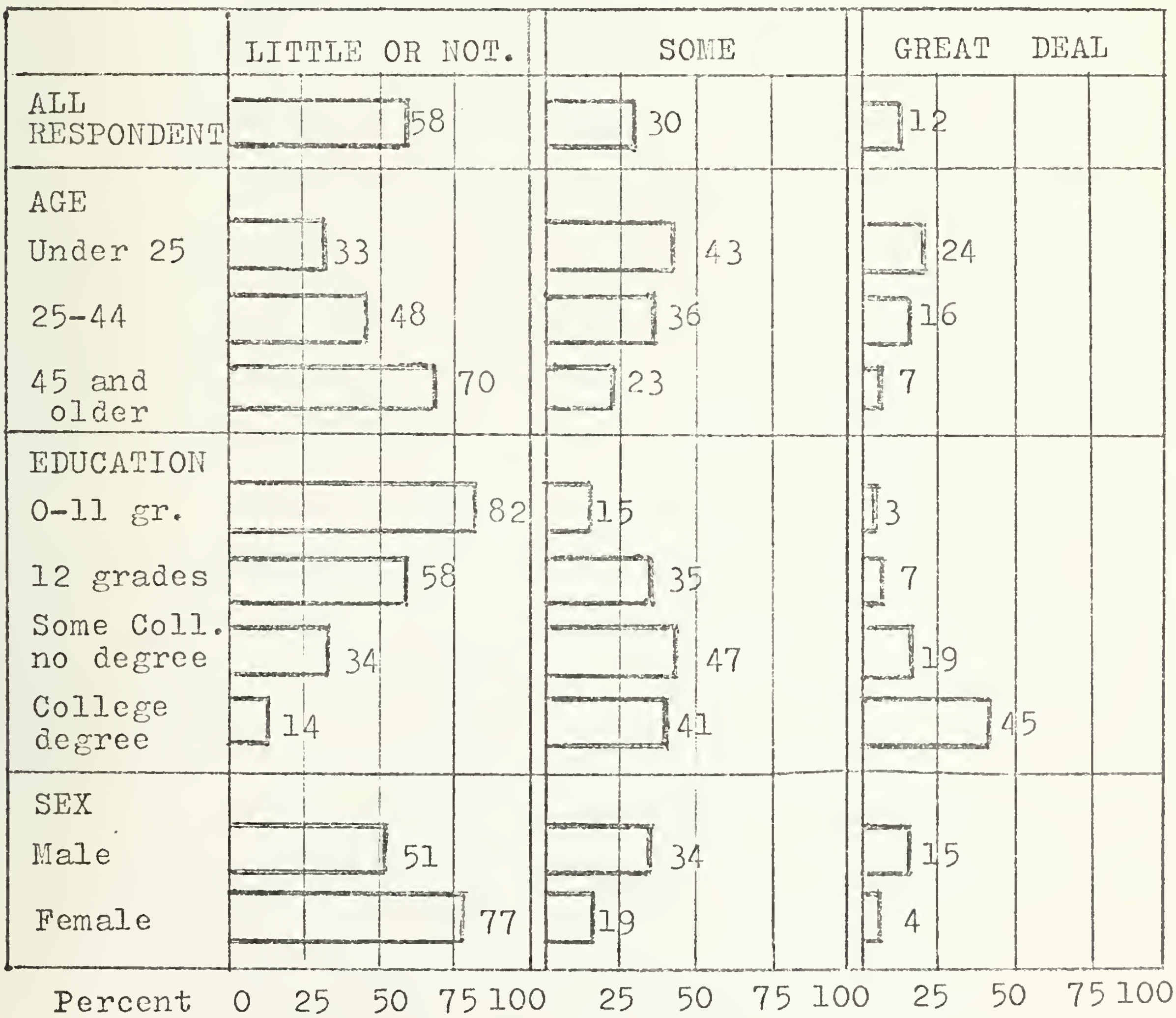
(4) "The more people know about the metric system the more they favor it."

PUBLIC ATTITUDES TOWARD METRIC

The More People Know About Metric The More They Like It



How Much The Public Knows About The Metric System



Source: Survey Research Center, Institute for Soc. Res. 1971

Fig. 2-3

Rather consistently, those with more formal education or more experience using metric units seemed the most confident that they could master it with little difficulty and believed that metric conversion was in the best interest of the U.S. For these reasons the surveyors judged that a program of public education would be essential to "the success of a national conversion program" [Ref. 1, Pp. 79-81].

f. The Length of the Change Over Period

The clear consensus for the length of the conversion period was ten years. At the end of this period the nation would be predominantly (not exclusively) metric.

Although some participants preferred a faster change and a few wanted more time, all could be accommodated by a ten year transition period. Those who needed more time could take it, since the nation's goal in a ten year program would be to become mostly (not entirely) metric.

Fifty percent of responding manufacturing businesses preferred a transition period of six to ten years, while most non-manufacturing businesses were in favor of a shorter period. The commercial weights and measures industries might need more time for the conversion.

The Department of Defense stated that the rate of conversion within the Department will be dependent on how well conversion is carried out by industry.

Seventy-two percent of responding Federal Civilian Agencies preferred a ten year transition period (Table 2-6).

Table 2-6: Choice of Optimum Period for Metric Changeover

	10 Years	Less than 10 Years	More than 10 Years
Manufacturing Industry	50%	24%	26%
Federal Civilian Agencies	72%	23%	5%

In summary, answer to the three fundamental questions posed earlier is the clear-cut consensus of the participants in the U.S. Metric Study that:

- Increased use of the metric system is in the best interest of the U.S.
- The nation should change to the metric system through a coordinated program.
- The transition period should be ten years, at the end of which the nation would be predominantly metric.

8. Benefits and Costs

Benefits and costs of the metric conversion can be tangible, direct or indirect. There seem to be two possible ways to compare them:

- to add all costs and all benefits to obtain a simple aggregate figure representing the net benefit (or cost) to the nation of going metric under a coordinated national plan.

- to determine which is more advantageous to the nation: deliberately going metric by plan, or eventually going metric without a plan.

The first approach, although conceptually simple, was not feasible. First, few of the groups from whom benefit and cost data were solicited were able to furnish them. Second, the benefits and costs are not directly comparable, inasmuch as they would occur at different times. Virtually all the costs would be incurred during the transition period, while most of the benefits would come after the transition. Third, the majority of benefit and cost items are basically elusive — perhaps even unknowable in dollar terms due to their intangible or indirect nature.

a. Comparative Analysis

As the main objective is not to arrive at absolute figures for benefits and costs, the U.S. Metric Study has adopted the second approach. This requires a comparative analysis showing a clear-cut differential between two aggregates whose values can be stated only in relative terms.

Information from the surveys of the manufacturing industry and of international trade, permit such a comparative analysis by deriving the costs if the change were made without a plan and the benefits from estimates of the time required to recoup costs.

The diagram in Figure 2-4 illustrates the advantages to the manufacturing industry of changing to metric

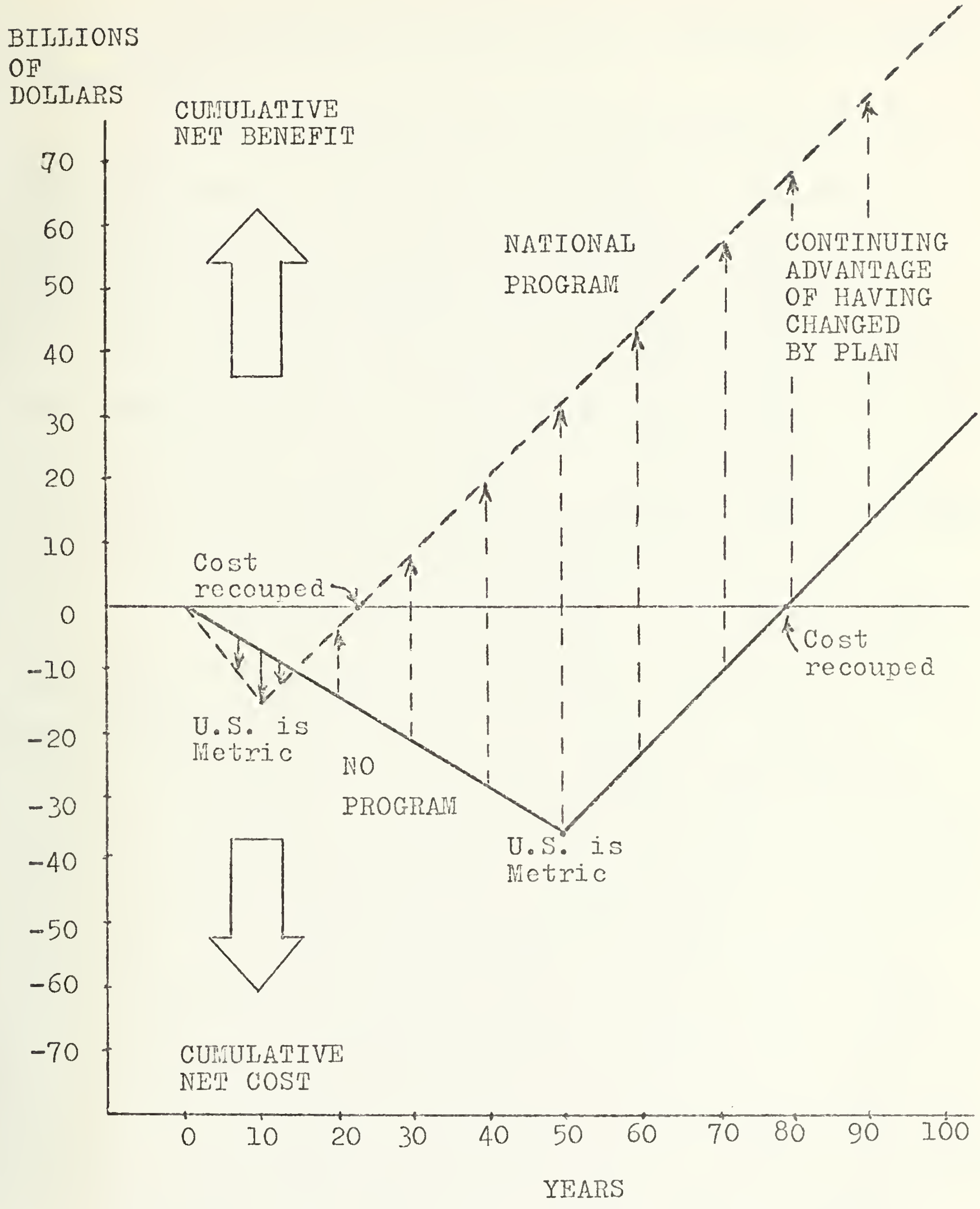


Fig. 2-4: The Economic Advantage of Going Metric by Plan - Manufacturing Sector

through a coordinated national program rather than changing without one.

In the diagram, two curves represent the cumulative net benefit and cost (vertical axis) over time (horizontal axis) of the metric changeover. The upward (positive) direction denotes the benefit, the downward (negative) direction the cost. The dotted curve represents the change through a coordinated national program, the solid curve the change without program. The dotted arrow area indicates the advantage of having changed by plan, the solid arrow area the advantage of the change without a plan.

A limited number of conservative assumptions have been added to the data collected. First, there are two assumptions as to time. The transition period of a planned changeover is taken as ten years. The transition period for changeover without a plan, based on the rate that the use of metric system is now increasing, is estimated at 50 years. The actual period might be longer or shorter, but the assumption of time is not critical to the outcome of the analysis. As the transition period of the change by plan is always shorter than that of the change without plan (this is one of the main reasons to have a plan), the diagram can be changed as to time (i.e. moving side to side the points marked "U.S. is metric") and the dotted arrow area is still greater than that of the solid arrows.

The assumptions as to benefits and costs were made on a "worst-case" basis. That is to say, when a choice

was possible, it was made so that the no-plan mode of changeover was put in the best light.

Two kinds of costs were identified for the changeover:

- average annual cost of maintaining dual capability (about $0.5 billion per year)
- total cost for all other manufacturing, called the "Base" cost. Any value can be assumed for this kind of cost.

An important reason for having a planned program is to reduce these two kinds of costs. However, as an element in the worst-case approach, these costs of the no-program changeover are assumed to be equal or lower (annually) than those of the change by plan.

The "Base" cost in the case of Figure 2-4 is assumed to be $1 billion annually (or $10 billion in total) for the change with a program, and $0.2 billion annually for the no-program changeover. The combined annual cost is given in Table 2-7.

Based on the $600 million increment in international trade balance mentioned earlier, augmented by an economic multiplier (2 to 3), and on the recoupment of costs furnished by a number of manufacturing companies, the benefits of the changeover were estimated at $7 billion in 6 years. This gives the slope (upward) of the curves after the points marked "U.S. is Metric."

Table 2-7: Assumed Average Annual Costs (Billions of Dollars)

	Program	No-Program
"Base" Cost	1.0	0.2
Dual Capability Cost	0.5	0.5
Combined Cost	1.5	0.7

Estimates from 126 manufacturing firms indicated that the actual cost figure probably lies somewhere between $6.2 billion and $14.3 billion. In the final analysis, however, the important point is that it will be less costly and the benefits will come sooner, if the nation changes to metric by plan rather than leaving the change to chance [Ref. 1, P. 110].

b. Cost Estimates from Other Sectors

(1). Federal Government. The cost estimates were made in two surveys: one concerning the Department of Defense alone, the other concerning 55 other agencies.

The 55 Federal civilian agencies contributed information that indicated costs attributable to extra efforts during a metric change in a national program would be about $60 million annually over a ten year period. There was no information as to the cost of change without a program.

The Department of Devense estimated that appropriations for D.O.D. over a 30 year period would have to be increased by a total of $18 billion, about 75 percent of it during the first 10 years. The cost of the change without a program was not estimated. However, the analysis of the manufacturing industry suggests that the change without a national program would cost more to the D.O.D. than the change by plan.

(2). Non-Manufacturing Businesses. Conducting no formal benefit-cost studies like those in the manufacturing survey, most of the non-manufacturing companies foresaw no significant change in their annual costs. It was not possible to make a comparative analysis between a planned metric changeover and one without a plan, in terms of benefits and costs.

The total cost of adapting or replacing weighing and measuring devices, which would be borne largely by non-manufacturing businesses, is estimated at about $340 million.

(3). Labor. Labor unions are concerned about possible costs to their members for new tools and retraining. They suggested that these expenses should be borne by employers. On the other hand, some self-employed craftsmen have to buy new tools as the nation changes to metric — regardless of whether there is a national program.

A more subtle cost, which can be termed "loss of experience", is also of deep concern. A worker who is unfamiliar with metric tools or estimation in metric has to work more slowly and less surely, therefore not quite so productive for a while. No dollar estimate was given for this "loss of experience", but the problem should be dealt with equitably in the design of a national plan.

(4). Education. In this sector, the costs of a metric changeover are considered to be largely compensated by the benefits of it. The change of textbooks and equipments would cost about $1 billion, but most textbooks are replaced anyway after a few years of use, thus most of the $1 billion could be completely absorbed.

The cost of training teachers who are not familiar with the metric system would be absorbed through the programs of continuing education.

The intangible benefits of going metric might well be substantial, mostly because of the simplicity of the metric system. As it can be learned more easily, the extra time that could be saved will be used for teaching other subjects.

The cost of the change to metric will be substantial, but it is indicated that the change has occurred and will continue with or without a national program. As the analysis showed that a change without a plan would cost more, it would be better to undertake the changeover through a carefully planned national program.

9. <u>Experience from Britain and Japan</u>.

The largest industrial countries that have changed to the metric system after World War II are Japan and Britain. Each approached conversion in its own way which would not serve as an exact model for the U.S., but there are lessons to be learned from both.

a. Japan's Approach

Having three recognized measurement systems: metric, English, and traditional, in 1921 Japan extended the use of the metric system by law. Plans were made with a ten year period for some sectors and twenty years for the others. Interrupted first by the depression and by the war, the changeover was not completed until the early 1960's.

The Japanese made the metric system compulsory by edict of the Diet in the Measurement Law of 1951. Much of the final planning was directed by a Metric System Promotion Committee, a quasi-public agency.

If the U.S. decides to go metric by plan, two lessons can be eearned from Japan's experience. The educational effort begun in the schools more than a generation earlier greatly facilitated the final changeover. However, educating just the children was not enough. The repeated stalling of the program in Japan was largely due to the lack of the strong promotional effort in the initial stage.

b. Britain's March to Metric

The British took much longer to make up their minds, but once they decided to go metric, they moved steadily

forward. After a motion for conversion program was defeated by only five votes in 1871 there were a number of debates in Parliament until 1907. Going metric or, as the British say, "metrication", was not seriously considered again until 1950, the date of the report of a departmental committee on weights and measures. Recommending metrication, the report had little immediate impact because British industry and commerce were against making a change while the U.S. and most of the Commonwealth still adhered to inches and pounds.

When more and more countries shifted to the metric system, the balance of opinion shifted rapidly. In 1965 the Federation of British Industries informed the Government that the majority of firms favored adoption of the metric system as the primary and, ultimately, the only method of measurement to be used. The Federation asked support from Government and obtained a favorable response.

After more than two years of planning, the metrication started in 1968 and has almost been completed in 1975.

The Metrication Board, a purely advisory body which reflects the interests of various sectors of society, was established to guide, stimulate, and coordinate the planning for the transition. As for the expense of conversion, "the costs of adopting metric must lie where they fall" [Ref. 1, P. 123].

Metrication programs have been established for almost all sectors. For electrical and engineering industries, metrication took four to seven years to complete. For other industries and businesses, it took four years or less.

From the start, the British have counted heavily on the educational system to make metrication smoother and longer lasting. Children learn to think in metric terms when entering primary schools. Vocational and technical schools design their curricula to the needs of specific industries.

A main goal of the metrication has been to persuade the British people to "think meter" rather than to go through the tedious process of converting inches and pounds through arithmetic calculations. Newspapers, radio and T.V. broadcastings, posters, exhibitions, advertising campaigns, local meetings and study groups have been encouraged.

Translating British experience directly to U.S. problems would be unrealistic since the British economy is smaller and less complex, and Britain has joined the Common Market which is wholly metric. On the other hand, Britain is, like the U.S., an advanced industrial nation and one with which the U.S. shares many common traditions. At least to this extent, the British metrication effort serves as a pilot program for the U.S.

B. INNOVATION

As mentioned in the previous section, the metric system has been in use in the world for almost two centuries. It is not new to the U.S. either. And one might wonder how could its adoption to this country be considered as an innovation.

It is true that the metric system is not new to many countries in the world. To several other countries, however, it is rather new. This is the same for organizations in the U.S.: some of them are familiar with this system of measurement, but for most of them its adoption would require innovation processes. Even within organizations, as mentioned in the Introduction, the metric system is new to some departments while to others, it is not. In addition, the goal is to implement the SI metric system which is new even to the organizations that are using the "old" metric system.

Innovation has been defined by some authors as the successful utilization of something "new to an organization" [Ref. 20, P. 6 and 7], or even "new to a situation" [Ref. 21, P. 112]. And the idea of innovation should be separated from the idea of invention. According to Shepard, "when an organization learns to do something it did not know how to do before, and then proceeds to do it in a sustained way, a process of innovation has occurred" [Ref. 22, P. 470].

In his study to identify the determinants of innovation in organization [Ref. 21, P. 113], Mohr pointed out some important variables, measured at the individual level, found to be related to the type of innovative change by many authors. Chief among these are the attitudes of an individual toward change. This factor was found to be important by Blau, Fliegel, Rogers, and Eisenstadt. In addition, the "cosmopoliteness" of an individual is reported to be a significant correlate of innovation by Mytinger and by Rogers.[2] Blau found both the competence of an individual and his material and status interests to be associated with innovation. A positive professional orientation was found by Rogers to be associated with innovation, as was opinion leadership status within a relevant communications network. Mohr found that innovation is directly related to the motivation to innovate, inversely related to the strength of obstacles to innovation, and directly related to the availability of resources for overcoming such obstacles [Ref. 21, P. 114]. Motivation was found to relate to the attitudes for innovativeness, activism, and ideology of the manager (health officer in this case). Organizational obstacles to innovation seemed to be associated with the extent of training of key

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[2]Rogers' theory on innovation diffusion will be discussed later in this section.

lower echelon employees -- and organizational capacity to handle the supervisory aspects of the new programs. This factor constituted an obstacle primarily when the manager was motivated to innovate. When the motivation to innovate was low, the correlation between progressive programming and the training of supervisors was low too [Ref. 21, P. 119].

Discussing the process of innovation in innovation-resisting organizations, Shepard stressed the importance of top management support, outside and inside sources of support, and organizational crisis [Ref. 22, P. 471-3]. The first factor, top management support, could be "shunned" by some strategies, such as to conceal the innovation from the rest of the organization, or gained by demonstration to top management. Outside and inside sources of support are often used by the successful innovator in acquiring a critical mass of support. Since innovation is not a respectable undertaking in innovation-resisting organization, the innovator should choose respectable friends to support him. Radical innovations are most readily adopted and implemented in time of organizational crisis, probably due to external threat to the survival of the closed organizational system. Hence the innovator should choose the "right time" or help to generate a crisis in order to create conditions favorable to the adoption and implementation of his innovation [Ref. 22, P. 473]. This point was shared by Wilson when he stated that "many organizations will adopt no major innovation unless there is a 'crisis'" [Ref. 20, P. 42].

Innovation is a process by which a new idea is adopted to an organization. This new idea need not be generated by the organization, but there must be some process to transfer it from the source of creation or invention to the ultimate users or adopters. This process is known as diffusion.

The diffusion of innovations was treated in depth by Rogers, based on over five hundred diffusion research studies [Ref. 23].

There are four crucial elements in the diffusion of innovations: (1) the diffusion, (2) its communication from one individual to another, (3) in a social system (4) over time. There is a continuum of type of adoption decision ranging from individual choice to group decision. In a social system there are norms which may be traditional and discourage the adoption of new ideas, or it may be modern and encourage the use of innovation. There are individuals from whom others seek information and advice. They are called opinion leaders and can be found by using sociometry. Opinion leaders may play an important role in diffusion of new ideas. As the idea may come from an external source, an individual whose orientation is more external than that of the others is said to have a higher degree of cosmopoliteness. A change agent is a professional person, usually representing an external organization, who attempts to influence adoption decisions in a direction that he feels is desirable, which may be favorable or unfavorable to the adoption. The adoption

process is the mental process through which an individual passes from first hearing about an innovation to final adoption. Innovativeness is defined as the degree to which an individual is relatively earlier in adopting a new idea than the other members of his social system. Adopters are classified into five categories on the basis of innovativeness: innovators, early adopters, early majority, late majority, and laggards [Ref. 23, Pp. 12-19].

Research on diffusion was reviewed by Rogers in various fields, of which two findings might be of interest to this study. In education, the best single predictor of innovativeness among schools was found to be educational cost per pupil. The "time lag", required for the wide spread adoption of new educational ideas had an average of 25 years which was rather high (compared to 3 years of average for adoption of most products in agriculture, industry and household). The possible reasons for this considerable lag were: absence of a scientific source of innovations, lack of change agents and economic incentive to adopt. In industry, factors found to be related to innovativeness included: a favorable attitude toward science (evidenced by status given scientists in the firm), cosmopoliteness (worldwide travel of executives, lack of secretiveness with plant visitors), adequate information (subscriptions to scientific journals, contact with universities), high growth rate of the firm, lack of "shop-floor resistance to innovation" (conservatism of foremen and union resistance) [Ref. 23, Pp. 39-44].

As mentioned above, norms may be traditional or modern. In general terms, the difference between social systems having these two "ideal types" of norms is characterized by the degree of development and complexity of technology, the economic rationality in planning and decision, the level of education, cosmopoliteness and ability to empathize of their members. An individual's innovativeness was found to vary directly with the norms of his social system on innovativeness [Ref. 23, Pp. 61-71].

There is a general similarity between the adoption process and the learning process.[3] Learning is defined as the relatively enduring change in the response to stimulus. In the adoption process, various stimuli about the innovation reach the individual from communication sources and cumulate until he responds to these stimuli, and eventually adopts or rejects the innovation [Ref. 23, P. 77].

There are five stages in the adoption process: awareness, interest, evaluation, trial, and adoption. (1) At the <u>awareness stage</u> the individual is exposed to the innovation but lacks complete information about it. <u>Cosmopolite and impersonal information sources</u> are most important at this stage (impersonal communications are usually spread via mass media). (2) At the <u>interest stage</u> the individual becomes interested

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[3]Learning theories will be reviewed in the next section.

in the new idea and seeks additional information about it. (3) At the evaluation stage, the individual weighs the advantages and disadvantages of the innovation and decides whether or not to try it. Localite and personal (face-to-face) information sources are most important at this stage. (4) At the trial stage the individual uses the innovation on a small scale in order to determine its utility in his own situation. (5) At the adoption stage the individual decides to continue the full use (100 percent utilization) of the innovation. An innovation may be rejected at any stage in the adoption process. A discontinuance is a decision to cease an innovation after previously adopting. Relatively later adopters are more likely to discontinue innovations than are earlier adopters. Adoption of new ideas varies directly with exposure to the new idea, however the effect of selective exposure is also important.

Awareness occurs at a more rapid rate than does adoption in a social system. There is little evidence that lack of knowledge about innovations actually delays their adoption. The first individuals to adopt innovations require a shorter adoption period than do relatively later adopters. The portion of the adoption period from awareness to trial is longer than from trial to adoption [Ref. 23, Pp. 81-120].

The rate at which an innovation diffuses and is adopted is affected by its characteristics, as perceived by the individuals in a social system. Rogers pointed out five

characteristics to be utilized: (1) relative advantage, (2) compatibility, (3) complexity, (4) divisibility, and (5) communicability. Relative advantage is the degree to which an innovation is superior to the ideas it supercedes. Crises may emphasize the relative advantage of an innovation and affect its rate of adoption. Compatibility is the degree to which an innovation is consistent with existing values (such as cultural norms) and past experiences of the adopters. Complexity is the degree to which an innovation is relatively difficult to understand and use. Divisibility is the degree to which an innovation may be tried on a limited basis. This characteristic is more important to relatively earlier adopters than to later adopters. Communicability is the degree to which the results of an innovation may be diffuse to others. The rate of adoption of new ideas is affected also by the interaction effect between individuals in a social system [Ref. 23, Pp. 121-139].

On the basis of innovativeness, individuals in a social system are found to be normally or nearly normally distributed and can be clasified into five categories: innovators (first 2.5%, to the left of $Z = \overline{X} - 2\sigma$), early adopters (next 13.5%, between $\overline{X} - 2\sigma$ and $\overline{X} - \sigma$), early majority (next 34%, between $\overline{X} - \sigma$ and $\overline{X}$), late majority (next 34%, between $\overline{X}$ and $\overline{X} + \sigma$), and laggards (remaining 16%). These five categories are ideal types, each of which has a dominant value: innovators, venturesome; early adopters, respect; early majority,

deliberate; late majority, skeptical; and laggards, traditional. Compared to later adopters, earlier adopters tend to have:

- younger age
- higher social status
- more favorable financial position
- more specialized operations
- a different type of mental ability
- more cosmopolite social relationships
- more opinion leadership
- contact with more impersonal and cosmopolite information sources which are in closer contact with the origin of new ideas
- contact with a greater number of different information sources [Ref. 23, Pp. 148-191]

Personal influence is face-to-face communication between the communicator and the receiver which results in changed attitudes or behavior on the part of the receiver. Personal influence from peers is most important (1) at the evaluation stage in the adoption process, (2) for relatively later adopters than for earlier adopters, and (3) in uncertain situations rather than in clear-cut situations. The three types of selectivity (in exposure, perception, and retention) partially explain why personal influence functions more effectively than mass media in overcoming resistance to change. Opinion leader plays an important role in the diffusion and adoption

of innovations. New ideas may flow through mass media channels to opinion leaders and from them to their followers in a two-step or multistep flow. Three methods have been utilized to measure opinion leadership: (1) sociometry, (2) key informants, and (3) self designating scales. Opinion leaders conform more closely to social system norms than the average member. They use more impersonal, technical accurate, and cosmopolite sources of information than their followers. They are more cosmopolite, have more social participation and higher social status, and are more innovative than their followers. Each adopter category is mainly influenced by individuals of the same or a more innovative adopter category [Ref. 23, Pp. 208-247].

The change agent serves as a communication link between a professional system and his client system. The extent of promotional efforts by change agents is directly related to the rate of adoption of an innovation. Commercial change agents are more important (1) at the trial stage than at any other stage in the adoption process, and (2) for earlier adopters than for later adopters at the trial stage. Change agents have more communication with higher-status than with lower-status members of a social system.

A general strategy of change was suggested which included the following: (1) a program of change should be tailored to fit the cultural values and past experiences; (2) a change agent's clients must perceive a need for an innovation before

it can be successfully introduced; (3) change agents should be more concerned with improving their clients' competence in evaluating new ideas, and less with simply promoting innovations per se; (4) change agents should concentrate their efforts upon opinion leaders in the early stages of diffusion; and (5) the social consequences of innovations should be anticipated and prevented if undesirable [Ref. 23, Pp. 254-282].

To predict innovativeness, two methods have been used with some success: multiple correlation and the configurational approach. Multiple correlation is a statistical method whereby a series of "independent" variables are related to one "dependent" variable (innovativeness in the present case). The goal is to explain a maximum of the variation in the dependent variable. It is possible to determine the relative contribution of each independent variable in explaining the dependent variable. Four criteria should be employed in selecting variables in a multiple correlation prediction analysis: (1) each independent variable should be highly related to the dependent variable, (2) each independent variable should have a relatively low interrelationship with each other independent variable; (3) the total number of variables should be minimized because of the amount of computational effort required and to increase practicality, and (4) there should be a theoretical and practical relevance for the relationship of each independent variable with the dependent variable.

The second method, configurational approach, consists of dividing a sample of respondents into relatively homogeneous subsamples on the basis of each of several independent variables. Each subsample is regarded as a separate unit for analysis since it has a unique configuration of independent variables. After successive breakdowns on the basis of the independent variables, which are usually dichotomized or tricotomized, the probability of a desired outcome is calculated [Ref. 23, Pp. 285-295].

C. LEARNING

To adopt the metric system, an individual should lose a habit (use of the customary system of measurement) and acquire a new one (use of the metric system). This permanent change is known as the learning process.

Learning is conceived as <u>conditioning or reinforcement</u> by S-R associationists (the neobehaviorists), and as <u>development of insight</u> by Gestalt-field psychologists [Ref. 24].

Since learning arises from an interplay of organisms and their environments, the key concepts of neobehaviorists are stimulus (provided by environment) and response (made by an organism). Neobehaviorists use "conditioning" or "reinforcement" to describe the learning process. Conditioning results in formation of conditioned responses. Conditioning implies a principle of adhesion; one stimulus or response is attached to another stimulus or response so that revival of the first evokes the second. Reinforcement is a special kind

of conditioning within which evocation is increased (reinforced) by reduction of a need of a drive stimulus. There are two kinds of positive conditioning — classical and instrumental — and a negative conditioning process — extinction. Through classical (Pavlov's experiment) and instrumental conditioning (Thorndike's experiment with rewarding stimulus), an organism gains responses or habits; through extinction it loses them.

The key word of Gestalt-field psychologists in describing learning is insight. They regard learning as a process of developing new insights or modifying old ones. Insights occur when an individual, in pursuing his purposes, sees new ways of utilizing elements of his environment, including his own body structure. The noun "learning" connotes the new insights — or meanings — which are acquired. Gestalt-field psychologists view learning as a purposive, explorative, imaginative, and creative enterprise, in contrast with the idea that learning consists of linking one thing to another according to certain principles of association. In a broad sense, a hypothesis usually is defined as a special kind of verbal insight. Insights are always a learner's own which is usable to him only if he can "fit it in" [Ref. 24].

In his book on the conditions of learning [Ref. 25], Gagné classified learning into eight types: signal learning, stimulus-response learning, chaining, verbal association,

discrimination learning, concept learning, rule learning, and problem solving.

Signal learning is based on the Pavlovian conditioned response. The responses are general, diffuse, and emotional ones. In order for signal learning to occur, there must be a natural reflex, typically reflexive emotional response on the part of the learner. The conditions for signal learning that can be externally controlled are those of contiguity and repetition [Ref. 25, P. 37, 98].

Stimulus-response learning involved making very precise movements of the skeletal muscles in response to very specific stimuli or combinations of stimuli (voluntary response). A process of discrimination is an integral part of this kind of learning. This type of learning is called trial-and-error by Thorndike, or operant learning notably by Skinner, or instrumental learning by many writers. In this form of learning, some of the important stimuli are internal and can be represented as: $Ss \rightarrow R$ (s stands for internal stimuli). The condition of stimulus-response learning is that there must be a terminating act which provides satisfaction (or reinforcement) [Ref. 25, Pp. 38-40, 104-109].

The third type of learning, chaining, is a matter of connecting together in a sequence two (or more) previously learned $Ss \rightarrow R$'s. This type is extremely simple and widely occurring. For the learner, the conditions of learning require that each individual stimulus-response connection

be previously learned. For the learning situation, the main condition for the establishment of a chain is getting the learner to reinstate the links one after the other in the proper order. Individual links should be executed with contiguity and repetition [Ref. 25, Pp. 42, 124-131].

The fourth type of learning, verbal association, can be classified as a subvariety of chaining since it is chaining used in language. The learning of an association between two verbal elements, called paired-associate learning, is of common use and usually needs intervening links (mediation) to be efficient. The conditions for optimal learning of this type require that each link of the chain and the mediating connections between verbal units must have been previously learned; the verbal units must be presented in the proper sequence, and the learner must actively make the responses required by the chain [Ref. 25, Pp. 134-141].

In discrimination learning, the fifth type, each stimulus must be distinguished from other stimuli in order to give different responses. Discrimination learning is often concerned with distinctive features. The conditions for optimal learning is that the learner must have previously acquired, in isolation, each of the chains that make up the set to be learned; the initial stimulus links must have been previously discriminated from each other and that the response links must also have been previously learned as discriminated $Ss \rightarrow R$ connections. The entire set of stimuli that are to be associated in different chains must be presented to the learner one by one [Ref. 25, Pp. 157-167].

The sixth type, concept learning, consists of classifying stimulus situations in terms of abstracted properties like color, shape, position, numbers, and others; or, in other words, "of putting things into a class". This type seems to be the opposite of discrimination learning. Prerequisites to the learning of concepts are capabilities that have previously been established by multiple discrimination. A set of chains must have previously been acquired to representative stimulus situations that exhibit the characteristics of the class which describes the concept, and that distinguish these stimuli from others not included in the class. The condition of reinforcement and contiguity is also of importance [Ref. 25, Pp. 171-181].

In the seventh type, rule learning (also called "principle learning"), the individual learns about rules which are a chain of two or more concepts. The main condition for this type of learning is that the concepts to be linked must have been previously established. The major external conditions of rule learning are embodied in verbal instructions which require the performance to be expected when learning is completed, and invoke recall of the component concepts. Contiguity and reinforcement appear also to be important, while repetition does not [Ref. 25, Pp. 56, 57, 195-203].

In the eighth and last type of learning, problem solving, the individual combines the rules he has already learned into

new ones and solves problems that are new to him. By doing so, the individual can deal with and control his environment and, more importantly, he can think. The conditions for problem solving require that the learner be able to recall the relevant rules previously learned. Contiguity of the rules that are to be "put together" to achieve solution is another important condition for this type of learning. Problem solving also needs verbal instructions which stimulate recall of relevant rules and "guide" or "channel" thinking in certain directions [Ref. 25, Pp. 59, 215-224].

The learning of a new intellectual skill is maximally facilitated (positive transfer) when there exists prior mastery of another intellectual skill called a prerequisite. This pair of intellectual skills, one subordinate to the other, forms the basic functional unit of a <u>learning hierarchy</u> which pertain to the internal conditions of learning. This concept provides the possibility of the <u>planning of sequences of instruction</u> within various content areas [Ref. 25, Pp. 65, 237-243].

Another way to classify learning is presented by Hall in his book <u>The Silent Language</u> [Ref. 26]. There are three types of learning: formal, informal, and technical. <u>Formal learnings</u> are acquired by precept and admonition. The adult mentor molds the young according to patterns he himself has never questioned. Formal patterns are almost always learned when a mistake is made and someone corrects it. Technical

learning also begins with mistakes and corrections, but it is done with a different tone of voice and the student is offered reasons for the correction. Entirely different in character from formal or technical training, informal learning uses a model for imitation. In many cases, activities are learned without the knowledge that they are being learned at all or that there are patterns or rules governing them. Technical learning, in its pure form, is close to being a one-way street. It is usually transmitted in explicit terms from the teacher to the student, either orally or in writing. Often it is preceded by a logical analysis and proceeds in coherent outline form. Unlike informal learning, it depends less on the aptitude of the student and the selection of adequate models, but more on the intelligence with which the material is analyzed and presented [Ref. 26, Pp. 63-72].

There seems to be some parallel between Gagné's and Hall's types of learning. Chaining and verbal association can be classified as informal training. Multiple discrimination, concept learning, rule learning, and problem solving fall in the category of technical training. Signal learning is part of formal learning, while stimulus-response learning can be considered as formal learning in some cases and technical learning in the others.

III. DEFINITION OF THE PROBLEM

It has been pointed out in the Introduction that, according to the U.S. Metric Study, going metric was not a question of "whether", but of "when" and "how". The question of "when" and "how" at the nationwide level has essentially been answered by the U.S. Metric Study as presented in the Review of the Literature (Section A). Briefly, the answer was: the U.S. would change to the International Metric System through a coordinated national program over a period of ten years, at the end of which the nation would be predominantly metric.

At the organizations' level, little answer has been provided thus far. One of the reasons for the delay was probably the wait for a congressional decision on the national policy concerning the metric system changeover. With the exception of a limited number of firms, no organization was willing to go metric without a coordinated program and many of them thought that a unilateral conversion to metric system would be impossible or too costly for them.

As mentioned in Subsection II, A.8 (Benefits and Costs), the later the start for going metric, the higher the cost. This gave the authors the feeling that the expected congressional decision would come soon or some actions from the U.S. industry would lead the way as the British have done

under the needs of the situation.[4] To be prepared for such a move, each organization should anticipate all the difficulties or problems it might encounter in the metric conversion and start to work for solutions unless it accepted to run the risk of higher cost.

Adoption of the SI Metric System within organizations poses two main problems: material and people.

The first problem deals with such matters as reevaluation of engineering standards; replacement or modification of weighing and measuring devices, tools, and machinery; manufacturing parts, nuts and bolts; updating or rewriting plans, specifications, and handbooks, etc... This is a problem of physical change.

The second problem, related to people, requires efforts in reducing opposition or resistance to the change of measurement system and engineering standards, promoting acceptance of SI Metric System, facilitating the process of unlearning the old system (U.S. Customary) and learning the new one (SI).

This study is limited to the second problem. It aims to enhance a smooth, rapid and economical change in human behavior with respect to measurement systems.

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[4]Just after this chapter had been written, the U.S. Senate and the House of Representatives each passed a bill "to make the metric system the predominant standard of weights and measures in the U.S." The adoption would be done in a period of ten years, on the basis of voluntary compliance [San Francisco Chronicle, December 9, 1975].

As in many kinds of adoption processes, the adoption of the metric system would be facilitated by the use of change agents who might be internal or external to the organization. Thus the problem consists first of selecting change agents and their assistants. In order to do that, it would be necessary to find out the factors which might help predict the best change agents and assistants.

The problem also consists of establishing a strategy for the education of people in the use of the SI Metric System. For any organization, time and energy are never unlimited. To obtain maximum results from the limited resources, it would be necessary to set up an order of priority for the best use of time and energy.

In summary, the problem consists of:

(1) selecting change agents and their assistants,

(2) establishing strategy for education,

(3) setting up an order of priority to spend time and energy for the adoption of the metric system,

(4) close examination of which types of learning are most appropriate for the adoption process.

IV. PROCEDURE TO COLLECT DATA

In the selection of change agents and their assistants, the degree of innovativeness and the knowledge of the innovation might be the first characteristic to be thought of. In many studies presented by Mohr [Ref. 21], Rogers [Ref. 23], and other authors, innovativeness was measured by the number or rate of adoption of the innovation. For the particular case of metric system changeover, no data related to the rate of adoption were available. Attitude toward the adoption of metric system has therefore been used as a prediction in the study. As suggested by Rogers [Ref. 23, Pp. 148-191] and some other authors [Ref. 21, Pp. 113-119], the other data to be collected were related to the age of the respondent, his education level, social status, family income, cosmopoliteness, religious preference, social relationship with superiors and subordinates. Cosmopoliteness, a rather abstract characteristic, was evaluated through other data such as: number of magazine subscriptions, number of T.V. education programs watched, frequency and distance traveled. In addition, the frequency and need of measurement was believed to be related to knowledge of the metric system and attitude toward the adoption. The reason for the respondent's attitude and the most important obstacles to the metric conversion, as seen by him, were also studied. The degree of knowledge and familiarity with the metric system of the respondent

were to be tested through a series of nine questions covering the common metric base units and basic rules of conversion. The knowledge about metric adoption in other countries, the frequency of handling metric equipment and thinking in metric units were considered as important elements of knowledge and, therefore, included in these nine questions. Finally, the need of training for the respondent himself and his organization in the use of metric system, as perceived by the respondent, was also investigated.

Twenty four questions, concerning the data mentioned above, formed a questionnaire [Appendix B] which was used as principal instrument for the survey.

About 1800 copies of the questionnaire were sent to three schools in the Monterey Peninsula area: Martin Luther King Junior High School (KJHS), Seaside High School (SHS) and Naval Postgraduate School (NPS), and to a food factory in Gilroy, California. The numbers of copies of the questionnaire sent out and responses received were listed in Table 4-1.

At the NPS, the questionnaires were sent to the professors and students and responses were received through mail boxes. At the Public Work Department (NPS) as well as at other organizations, the questionnaires were sent out and responses received through the intermediary of the managers or teachers. It is interesting to note that, with the exception of the food factory, the way of sending questionnaires and receiving

Table 4-1 Number of Questionnaires Sent Out and Responses Received

Organization	Number of copies sent out	Number of Responses	
		Absolute Quantity	Percentage
King Junior High School			
- Teachers	400	10	67%
- Students		258	
Seaside High School	280	170	61%
Naval Postgraduate School			
- Professors	80	31	39%
- Students	840	313	37%
- Public Work	100	42	42%
Food Factory at Gilroy	100	31	31%
Total	1800	855	48%

responses has influenced significantly the percentage of responses received. The professors and students at the NPS might feel "freer" to respond to the questionnaire when they received it by mail than the workers and school children who received it from their employers and teachers.

One hundred copies of the questionnaire were sent to a food factory in Gilroy, but only 31 responses have been

received. One of the reasons for this low percentage of responses might be attributed to the fact that most of the workers in the factory are Mexicans who could not read and write English.

At King Junior High School, the number of respondents constituted a sample of about 50 percent of the students of the mathematics classes, from seventh to ninth grade. At Seaside High School, the Departments of Math and Science have been teaching in the metric system for years with no significant difficulty. So the questionnaire was sent to the shop classes which were being taught exclusively in U.S. Customary system.

Students at the NPS were armed forces officers ranking from Lieutenant (jg) or First Lieutenant, to Commander or Lieutenant-Colonel. It would seem proper to consider them as managers rather than "pure" students.

Ninety percent of the respondents at the Department of Public Works were workers having a high need for measurement. Most of them were mechanics, electricians, pipefitters, motor vehicle operators, painters and gardeners.

Respondents at the food factory were mostly engineers, managers, laboratory technicians, quality control technicians, and clerks.

In total, there were 52 percent of those who received the questionnaire who did not respond. Besides the difficulty in reading and writing English of a number of workers

and young schoolchildren, no other reasons (as to why they did not respond) could be seen or inferred. Some respondents mentioned that those who were indifferent to the metric adoption would tend not to respond. This seemed to be unfounded since the percentage of those who answered as "neutral" to the question about attitude appeared to be quite high (37.7%, compared to the average of 20% for each of the five choices). There may have been some negative self selections of non response. However, the percentage of those who did respond (48%) was regarded by many people as relatively high for this type of survey.

To prepare for computer processing, the data were coded as described in Appendix C.

In addition to the written questionnaire, personal interviews were conducted with some managers and school teachers to obtain information about the organizations and their problems in going metric.

Data and information collected from the questionnaire and interviews are analyzed in the next chapter.

V. ANALYSIS OF DATA

The data collected was processed using the Statistical Package for the Social Sciences (SPSS) [Ref. 27]. Raw scores (coded as described in the last chapter and Appendix C) as well as standard or Z scores (converted from raw scores by using SPSS CONDESCRIPTIVE subprogram) were used in the process. Two types of analysis have been done: factor analysis with VARIMAX subprogram, and multiple regression with REGRESSION subprogram.

The data file (named METSVEY, N=855) was divided into four subfiles:

(1) High School Student (HISCHSDT): Students at King Junior High and Seaside High (N=428).

(2) Educator (EDUCATOR): Teachers at high schools and professors at the Naval Postgraduate School (N=41).

(3) Business (BUSINESS): Managers and workers at the food factory in Gilroy and at the Department of Public Works, Naval Postgraduate School (N=73).

(4) NPS Student (NPSSDT): Students at the Naval Postgraduate School (N=313).

A. DEMOGRAPHIC VARIABLES

1. Sex. (Sex of Respondent)

Sex	All	HS Student	Educator	Business	NPS Stud.
Male	78.1%	65.0%	87.5%	75.3%	95.5%
Female	21.9%	35.0%	12.5%	24.7%	4.5%

2. Age (Age of Respondent)

Age	All	HS Stud.	Educator	Business	NPS Stud.
18 or less	50.2%	99.8%	--	1.4%	--
19 - 25	3.3%	0.2%	2.5%	16.7%	4.5%
26 - 35	34.6%	--	30.0%	19.4%	86.2%
36 - 45	7.0%	--	45.0%	18.1%	9.3%
46 or more	4.8%	--	22.5%	44.4%	--

3. <u>Education</u> (Last Year of School Completed)

Education Level	All	HS Stud.	Educator	Business	NPS Stud.
Jr. High	42.0%	81.8%	--	12.3%	--
High School	12.3%	18.2%	--	35.6%	--
Jr. College	2.7%	--	2.4%	28.8%	--
College Grad.	30.1%	--	12.2%	11.0%	78.6%
Post.Grad.	13.0%	--	85.4%	12.3%	21.4%

4. <u>Occupation</u> (Occupation of Total Sample)

-- High School Student 50.1%

-- High School Teacher 1.3%

-- Worker 6.0%

-- Manager 2.2%

-- Professor 3.5%

-- NPS Student 36.8%

5. <u>Income</u> (Annual Family Income)

Income	All	HS Stud.	Educator	Business	NPS Stud.
Under $3000	3.7%	10.1%	--	--	--
$3000-$4999	2.7%	6.1%	--	4.2%	--
$5000-$6999	3.1%	7.3%	--	4.2%	--
$7000-$9999	7.8%	15.0%	--	12.7%	1.9%
$10,000-$14,999	26.0%	32.4%	12.2%	29.6%	22.0%
$15,000 and over	56.6%	29.1%	87.8%	49.3%	76.1%

6. <u>Religion</u> (Religious Preference of Respondent)

Religious Preference	All	HS Stud.	Educator	Business	NPS Stud.
Protestant	49.2%	48.3%	50.0%	28.6%	54.3%
Catholic	33.7%	38.6%	25.0%	41.3%	28.0%
Other	4.5%	5.3%	5.0%	4.8%	3.6%
No Preference	12.6%	7.8%	20.0%	25.4%	14.1%

B. RESULTS

1. Attitude (Toward Metric System)

A frequency distribution of responses on a five-point scale of attitude toward using the metric system gave the following results:

Attitude	All	HS Stud.	Educator	Business	NPS Stud.
(1) Strongly against	10.7%	16.4%	4.9%	15.1%	2.6%
(2) Mildly against	6.3%	7.7%	4.9%	11.0%	3.5%
(3) Neutral	37.7%	56.8%	19.5%	39.7%	13.5%
(4) Mildly in favor	19.1%	12.6%	29.3%	11.0%	28.5%
(5) Strongly in favor	26.2%	6.5%	41.5%	23.3%	51.9%

2. Knowledge (Of Metric System)[5]

A ten-item quiz formed the major part of the questionnaire (See Appendix B). The correct answers to these

[5]Note how both attitude and knowledge differ from the ISR results on pages 26 and 31.

questions were added together and gave sums ranging from 10 to 42. These final scores (names METKNLGE: metric knowledge) were used as raw scores and were converted to Z scores for future analysis. In the following table they are classified in subgroups:

Score on MS quiz	All	HS Stud.	Educator	Business	NPS Stud.
Very low (10-15)	46.8%	77.6%	9.8%	53.4%	8.3%
Low (16-20)	15.7%	16.5%	14.6%	20.5%	13.7%
Average (21-25)	9.6%	4.0%	4.9%	4.1%	19.2%
High (26-30)	8.0%	1.4%	17.1%	8.2%	15.7%
Very high (31-36)	10.7%	0.5%	26.8%	9.6%	22.7%
Highest (37-42)	9.2%	--	26.8%	4.1%	20.4%

3. <u>Measurement Need</u>

Respondents were asked how often they measured things in their work. This was an attempt to tap their need for any kind of measurement system. (Presumably a carpenter would have a greater measurement need than a philosopher.) Responses were categorized as follows:

Response	All	HS Stud.	Educator	Business	NPS Stud.
Never	4.6%	7.4%	--	4.1%	1.6%
Sometimes	53.1%	68.6%	48.8%	32.9%	37.6%
Often	42.3%	24.0%	51.2%	63.0%	60.8%

4. Perceived Need for Training

Respondents gave the following impressions of their perceived need for training:

Response	All	HS Stud.	Educator	Business	NPS Stud.
None or little	14.1%	3.8%	35.0%	3.3%	24.3%
Some	44.8%	37.5%	52.5%	36.7%	53.0%
A great deal	41.1%	58.7%	12.5%	60.0%	22.7%

5. Social Relations with Subordinates or Superiors

Still another way of assessing cosmopoliteness was to ascertain the degree of informal social activity of respondents with their subordinates or superiors. The raw data fell into the following categories:

Response	All	HS Stud.	Educator	Business	NPS Stud.
Never	41.0%	54.8%	19.5%	38.0%	26.6%
Sometimes	52.9%	40.3%	70.7%	54.9%	66.7%
Often	6.0%	4.9%	9.8%	7.0%	6.7%

6. Reading

Also considered to be related to the degree of cosmopoliteness of the respondent is the extent of his reading which was measured by the number of magazines the respondent subscribed to regularly.

Number of Magazines	All	HS Stud.	Educator	Business	NPS Stud.
None	43.2%	41.3%	--	30.4%	6.2%
1 or 2	33.3%	35.8%	10.0%	24.6%	20.8%
3 or 4	13.8%	18.2%	30.0%	26.1%	39.6%
5 or 6	6.0%	3.6%	22.5%	14.5%	20.5%
7 or more	3.7%	1.1%	37.5%	4.3%	13.0%

7. T.V. Programs

The number of education programs the respondent watched on T.V. each week was also used to assess his cosmopoliteness.

Number of Programs	All	HS Stud.	Educator	Business	NPS Stud.
None	43.2%	48.4%	35.1%	42.2%	38.1%
1 or 2	33.3%	25.2%	37.8%	34.4%	42.2%
3 or 4	13.3%	14.4%	16.2%	15.6%	12.2%
5 or 6	6.0%	5.7%	8.1%	7.8%	5.8%
7 or more	3.7%	6.2%	2.7%	--	1.7%

8. Traveling

Traveling was the last data used to estimate the degree of cosmopoliteness. The respondent was asked how often he travels out of town, out of state, and out of country.

Responses	All	HS Stud.	Educat.	Business	NPS Stud.
Never	1.1%	1.4%	--	1.4%	0.6%
Sometimes out of town	10.2%	16.7%	2.4%	17.8%	0.6%
Sometimes out of state or often out of town	25.9%	34.7%	24.4%	30.1%	13.1%
Sometimes out of country or often out of state	57.2%	43.6%	70.7%	45.2%	76.6%
Often out of country	5.6%	3.5%	2.4%	5.5%	9.0%

C. TREATMENT OF RAW DATA

The analysis of these scores required comparing across variables. Raw scores were thus converted to standard (Z) scores on interval or ordinal dimensions. Nominal data was reduced to presence or absence of a score (e.g. religion). Age was left in raw score form.

D. FACTOR ANALYSIS

It was of interest to the authors to obtain a global view of how many factors would account for the total variance of the list of variables and to what extent would the individual variables "load" onto those factors.

Traditionally the respective eigenvalue indicates the variance accounted for by each factor and is determined by $\sum_{j=1}^{n} a_{ji}^{2}$ where a_{ji}^{2} is the factor loading. The proportion of total variance accounted for by a factor is

$$\frac{\sum_{j=1}^{n} a_{ji}^{2}}{n} .$$

Using the Statistical Package for the Social Sciences (SPSS) the following results were obtained:

List of Factors	Eigenvalue	Percentage of Variance
* I	2.46494	30.8
* II	1.16557	14.6
* III	1.05396	13.2
IV	0.87776	11.0
V	0.77323	9.7
VI	0.71457	8.9
VII	0.60629	7.6
VIII	0.34365	4.3

* Considered Significant

After 13 iterations the rotated factor matrix showed the following loadings of the variables upon the three principal factors:

	Factor I	Factor II	Factor III
Education	0.85206	0.18152	0.08326
Income	0.67734	0.05967	0.07488
Religious Preference	0.03481	0.00859	0.37377
Reading	0.56682	0.18792	-0.32156
T.V. Program	0.00784	0.28673	-0.06016
Traveling	0.45754	0.10025	0.05284
Measurement Need	0.23729	0.42928	0.09051
Social Relation	0.10521	0.59104	0.03830

It will be noted that, when taking the entire sample into the analysis:

- education, income and reading loaded the most heavily on Factor I.

- measurement need and social relation loaded heaviest on Factor II.

- religion loaded heaviest on Factor III.

However, it seemed prudent to break the sample into subfiles of interest.

Subfile	Variables Accounting For More Than Forty Percent of the Variance of Three Principal Factors		
	Factor I	Factor II	Factor III
HS Student	Education Income Traveling	Measurement need TV Program	Religion
Educator	Education Income TV Program	Social Relation	Reading
Business	Education Social Relation Reading	Religion	Measurement Need
NPS Student	Social Relation	Reading	Religion

(see Appendix D for detailed values)

When age was introduced as a raw score, three factors again assumed eigenvalues of over 1.0 for the entire population.

After 11 iterations, the rotated factor matrix showed the following loadings of the variables upon the three principal factors:

	Factor I	Factor II	Factor III
Age	0.71698	0.09630	0.06887
Education	0.90348	0.16094	0.10768
Income	0.65985	0.07364	0.04660
Religious Preference	0.03361	0.00772	0.38951
Reading	0.55598	0.18896	-0.30245
T.V. Program	0.00390	0.29654	-0.06549
Traveling	0.42235	0.11793	0.02100
Measurement Need	0.23401	0.43562	0.09035
Social Relation	0.11116	0.47611	0.04040

This showed that age loaded heavily on Factor I. Breaking into subfiles, it loaded on Factor I and II as follows with age as a listed variable:

Subfiles	Factor I	Factor II
HS Student	Heaviest	
Educator	Negative	Heavily
Business		Heaviest
NPS Student	Heaviest	

Factor analysis, then, has helped to isolate which variables will probably be the best predictors for selecting change

agents as well as describing the stronger elements of cosmopoliteness within this sampled population.

E. MULTIPLE REGRESSION ANALYSIS

The authors proceeded to look at the effect at these variables upon attitude toward the metric system and knowledge of the metric system. (These had to be separate runs with attitude and knowledge as distinct dependent variables of interest.)

1. <u>Attitude Toward the Metric System as the Dependent Variable</u>

Subfile	Independent Variable	Beta	d.f.	F	
HS Student	Age	.07	1, 162	0.059	not significant
	Income	-.10		1.664	
	Education	.03		0.134	
	Religion	.03		0.179	
	Reading	.04		0.290	
	<u>Measurement Need</u>	.18		5.910	significant @ .025 level
Educator	Age	-.08	1, 33	0.170	
	Income	.14		0.474	
	Education	-.02		0.007	
	Religion	.10		0.388	
	<u>Reading</u>	.38		5.284	significant @ .05 level
	Measurement Need	.09		0.355	

Subfile	Independent Variable	Beta	d.f.	F	
Business	Age	-.29	1, 52	3.751	
	Income	-.01		0.007	
	Education	.39		7.272	- significant @ .05 level
	Religion	.17		1.521	
	Reading	-.28		3.429	
	Measurement Need	.10		0.645	
NPS Student	Age	-.08	1, 290	1.764	
	Income	-.14		5.702	- significant @ .05 level
	Education	.09		2.591	
	Religion	.12		4.699	-
	Reading	.09		2.490	
	Measurement Need	.15		6.880	- significant @ .025 level
Entire Profile	Age	-.21	1, 555	16.916	- @ .01
	Income	-.10		5.054	- @ .025
	Education	.45		81.073	- @ .01
	Religion	.08		4.592	- @ .05
	Reading	.06		1.900	
	Measurement Need	.15		14.419	- @ .01

Note: In the last subfile for the "Entire Profile", the phrase "significant @ .xxx level" was abbreviated to read "@ .xxx".

2. <u>Knowledge of the Metric System as the Dependent Variable</u>

Subfile	Independent Variable	Beta	d.f.	F
HS Student	Age	-.30	1, 162	1.270
	<u>Income</u>	.25		9.644 - @ .01
	<u>Education</u>	-.19		5.661 - @ .025
	Religion	.02		0.102
	Reading	.02		0.077
	Measurement Need	.11		2.208
Educator	<u>Age</u>	.36	1, 33	4.630 - @ .05
	Income	.31		3.159
	Education	.20		1.274
	Religion	.09		0.494
	Reading	-.05		0.158
	<u>Measurement</u> Need	.40		9.057 - @ .01
Business	<u>Age</u>	-.38	1, 52	6.436 - @ .025
	Income	-.11		0.627
	<u>Education</u>	.35		5.638 - @ .025
	Religion	.24		2.780
	Reading	-.16		1.074
	Measurement Need	.01		0.002

Subfile	Independent Variable	Beta	d.f.	F
NPS Student	Age	-.17	1, 290	7.678 - @ .01
	Income	.04		0.412
	Education	.05		0.874
	Religion	.16		7.979 - @ .01
	Reading	.07		1.696
	Measurement Need	.16		7.877 - @ .01
Entire Profile	Age	-.15	1, 555	10.939 - @ .01
	Income	.03		0.493
	Education	.53		136.803 - @ .01
	Religion	.09		6.690 - @ .01
	Reading	.06		2.557
	Measurement Need	.12		12.881 - @ .01

Note: In all subfiles, the phrase "significant @ .xxx level" was abbreviated to read "@ .xxx".

It is felt that when we are looking for internal change agents and change agent assistants within organizations and we are chiefly concerned with their attitude toward the metric system, we would pick those high on need for measurement among high school students; higher level of reading among educators; higher education level among businessmen; and greater need for measurement, lower income, and no preference for religion among NPS students. For the entire population, the factors which would seem to predict more

effective selection are education, age (negative), measurement need, income (negative), religion (no preference).

When <u>knowledge</u> of the metric system is the key focus, income and education (negative beta) are of prime importance with high-school students; need for measurement and age are most important to educators; age (negative) and education to businessmen; and religious preference, need for measurement, and age (negative) to NPS students. To the entire population, the most important elements are education, need for measurement, age (negative), and religious preference. These indicators for selection are summarized in Table 5-1.

Among these variables, education appears to be by far the most important in predicting both attitude toward and knowledge of the metric system. In the subgroup NPS Students, however, it is of lower importance. This might be explained by the fact that most respondents of this subgroup have been grouped in the same level of education (college graduate). In the subgroup Educators; beta weight was relatively high (.30) but the F factor was relatively low (1.274) for knowledge. The negative beta weight of this variable in the subgroup HS Students (relating to knowledge) seems to be inconsistent with its high positive beta weight in the entire population. It should be recalled that this subgroup consists of two components: the King Junior High School students of the math classes who are being taught partly in the metric system, and the Seaside High School students of the shop

Table 5-1 Indicators for Selection of Change Agents

Subfile	Attitude	Knowledge	Common to Attitude and Knowledge
HS Students	Measurement Need	Income Education (-)	
Educators	Reading	Measurement Need Age	
Business	Education	Age (-) Education	Education
NPS Students	Measurement Need Income (-) Religious Preference	Age (-) Religious Preference Measurement Need	Measurement Need Religious Preference
Entire Profile	Education Age (-) Measurement Need Income (-) Religious Preference	Education Measurement Need Age (-) Religious Preference	Education Measurement Need Age (-) Religious Preference

Notes: 1. Six of these variables are significant at the .05 level, six at the .025 level, the remainder at the .01 level.

2. Negative signs in parenthesis are those of the beta weight.

classes who work almost exclusively with the U.S. Customary system, and possess a lower knowledge of the metric system. (This holds even though they are at a higher level of education than that of the King Junior High students.)

Age can be considered as the second most important variable. With the exception of the subgroup Educator, it has a negative beta weight in all subgroups (not listed in Table 5-1 for HS Student because of the low F factor) as well as in the entire population with regard to knowledge of the metric system. An explanation might be found in the fact that the metric system has been introduced only recently in the U.S. schools and younger people have obtained more knowledge of it than those who left school earlier. For the educators it is different. Almost all of them (97.6%) are over 26 years of age and might have acquired their knowledge of the metric system from continuing education (a need for their teaching in metric) rather than from school. It seems logical that this knowledge increases with age. With this exception, the negative beta weight of age seems to justify one of Rogers' hypotheses which states that: "earlier adopters are younger in age than later adopters" [Ref. 23, P. 172]. Knowledge of the metric system (now in the U.S.) is here regarded as a measure of innovation adoption.

The need for measurement is also important as a predicting variable for all subgroups, except the businessmen where the need for measurement is uniformly high. This

need to measure might create in the respondents an interest in the metric system. Measuring in turn, may help this sample to learn the metric system and possibly to like it.

Income has a positive beta weight in the subgroup HS Students, but a negative one in the subgroup NPS Students and in the entire population. For the latter, it seems to act like age does (discussed earlier). This can be explained by the fact that the NPS Students in general, have their age, rank and income increase in the same direction. For the entire population, most of the older respondents are professors, managers and high ranking officers having higher income. It is also noted that the correlation coefficient between income and age is quite high (0.47).

The last variable to be considered, religious preference, has a very low beta weight in the entire profile, and a moderately low one in the subgroup NPS Students (.16 and .12). This indicates somewhat the relationship between no religious preference and cosmopoliteness as pointed out by some authors.

Taking into consideration the correlation coefficients and beta weights of these variables, it can be said that attitude toward the metric system is quite predictable by education, while knowledge of the metric system is influenced by the combination of education, age, need of measurement, income and level of outside reading.

It is also of interest to note that between attitude toward and knowledge of the metric system there exists a correlation coefficient (0.493).

Four possibilities of a causal effect might be assumed:

(1) positive attitude leads to more knowledge and negative attitude leads to less knowledge. (i.e. people know about the metric system because they like it, or they do not know much about it because they do not like it.) Or,

(2) knowledge determines attitude (i.e. people like the metric system because they understand it, or they do not like it because they do not understand it), or

(3) attitude and knowledge have a reciprocal causal effect (i.e. "both (1) and (2) above are true"), or

(4) as attitude and knowledge are both dependent variables, their correlation coefficient is merely due to their close relationship with the independent variables, especially with education (i.e. "all the above are false").

It seems difficult to determine the nature of this relationship. However, based on the reasons given by the respondents to explain their attitude toward the adoption of the metric system (question 13 of the Questionnaire, Appendix B), it is found that many respondents, mostly high school students, said that they were against the metric adoption because "it is too complicated", or "I do not know anything about it". On the contrary, many others,

mostly educators and NPS students explained their favoring of the adoption by saying that "it is quite simple and rational", or "the rest of the world has adopted it", or "to avoid being isolated from the rest of the world" (recalling that knowledge of the percentage of countries in the world that have converted to the metric system — question 14 of the Questionnaire — was included in the knowledge of the metric system). For these respondents, who constituted a large number, Assumption 2 (knowledge is the cause) seems to be supportable.

Finally, as mentioned earlier, personal interviews were also conducted with some high school teachers and managers.

Some teachers of mathematics and sciences at Seaside High School said that they were teaching almost exclusively in the metric system. The only problem seemed to be once leaving the class, the students would "switch" to the U.S. Customary system for other classes or for their everyday life needs, and saw almost no application of what they had learned. The teachers at the shop classes — which were taught exclusively in the U.S. Customary system — stated that the main problem lay in the providing of necessary funds to purchase new tools and equipment, rather in the learning process.

At King Junior High School, some teachers of mathematics found that it would be easier and faster to teach the

school children directly in the metric system (for example to show them a meter ruler and tell them to measure things with it) rather than to go through the tedious work of training them in the conversion of one system to the other. If measurement systems can be considered as a "language", the above concept seems to justify the "direct method" widely used in linguistics.

For the food factory in Gilroy, the problem consists of — as presented by some managers — replacement of tools and equipment (agricultural and manufacturing) and training of personnel. Training does not seem to be very difficult to them since most of its engineers and technicians, mostly the younger ones, have learned the metric system at schools and have obtained enough experience in the conversion to metric units during the manufacturing and packaging products for export.

In summary, the returned Questionnaires from the sampled population seem to indicate trends which, along with literature published by researchers in the field of innovation diffusion, may be used to construct a model to speed the adoption of the metric system in organizations.

VI. CONCLUSIONS – SUGGESTED MODEL – RECOMMENDATIONS FOR FUTURE RESEARCH

With the results of the analysis of the data, the information provided by the U.S. Metric Study, and the theories on innovation and learning process, as reviewed earlier, the authors can now proceed to formulate a suggested model to be used for the selection of change agents and change agent assistants, and a strategy for the education of people in the use of the SI metric system.

A. SELECTION OF CHANGE AGENTS AND THEIR ASSISTANTS

Internal change agents can be selected from members of the organization. In schools, they may be selected among the educators, and their assistants may be chosen from the students. In firms, change agents may be selected from managers and engineers, and their assistants from the supervisors and workers.

The change agents should have relatively high knowledge of the metric system, and preferably a favorable attitude toward it. In general, they can be selected from those who have:

- high level of education
- great need in measurement
- younger age
- no religious preference (see Table 5-1)

(For the educators, the factor of age should be replaced by the extent of external reading and continuing education as predictors).

In the selection of change agent assistants, the factor attitude might have to play a more important role. Although attitude and knowledge have almost all factors in common for the entire population, in the group of students (high school and NPS) attitude is characterized mostly by the need for measurement. In the subgroup Business, attitude is indicated almost exclusively by education, while knowledge is influenced more by age. Change agent assistants can therefore be selected among students having great need in measurement and workers having a high level of education.

As pointed out by Rogers, opinion leadership is also an important factor in the diffusion of innovation. For a general strategy of change, Rogers recommended that "change agents should concentrate their efforts upon opinion leaders in the early stages of diffusion" [Ref. 23, Pp. 254-282]. If internal change agents are to be selected, they might be chosen among opinion leaders.

In summary, the factors to be used in the selection of change agents and their assistants are:

- high level of education
- great need in measurement
- younger age (or reading and continuing education for the educators)
- absence of religious preference
- high opinion leadership.

B. STRATEGY FOR EDUCATION

To promote a rapid and economical adoption of the metric system, a strategy for the education of people may be worked out by finding the answer to the following questions:

- What is the most efficient priority in spending time, energy and money for the education?

- Which types of learning are most appropriate for the adoption process?

- How may one make the best use of change agents and their assistants?

- What actions should be taken in each stage of the adoption process?

1. Order of Priority

As resources in any organization are limited, it seems appropriate to determine an order of priority for their utilization in the adoption process.

It is believed that this order depends mainly on two factors: attitude toward and knowledge of the innovation. Using these factors to form a grid, the order of priority may be given as indicated by the numbers in the boxes on the following page (1 has the highest priority, 6 the lowest).

· Those who have some knowledge of the innovation but are against the adoption of it should be given least effort and energy in the adoption process because they might have the highest resistance to the change and lowest probability

		Low Knowledge of the Innovation	High Knowledge of the Innovation
Attitude Toward The Innovation	Positive	*3*	4
	Neutral	*2*	*1*
	Negative	5	6

of attitude change. However, if they were active in influencing people's opinion, their opposition might hinder the adoption process and neutralizing efforts must be employed. Rogers et al feel, however, that with normal conditions it is best to ignore this group. It is also found that those with little knowledge of the innovation and strong negative attitude (group 5) require an inordinate amount of programmatic energy for attitude change. Those with positive attitude and high knowledge of the innovation (group 4) are presumably "won over" and require only supportive attention. Those with low knowledge of the innovation but neutral attitude (group 2) or positive attitude (group 3) are considered to have the highest likelihood of change [Ref. 23, Pp. 242-248].

To predict who may be found in each segment of this matrix one may use the information gathered earlier in this study.

Within the subfiles which were observed in this study the following priorities for attention could be constructed:

<u>Group 1</u> (higher knowledge, neutral attitude)

HS Students: higher income, junior grades, moderate need for measurement.

Educators: highest need for measurement, higher income and age, moderate outside reading.

Business: younger, lower income, no religious preference.

NPS Students: younger, middle income, no religious preference.

<u>Group 2</u> (Neutral attitude, lower knowledge)

HS Students: lower income, moderate need for measurement.

Educators: younger, moderate outside reading, low need for measurement.

Business: older, religious.

NPS Students: older, middle income.

<u>Group 3</u> (Positive attitude, lower knowledge)

HS Students: highest need for measurement, older, low income.

Educators: youngest, highest level of outside reading.

Business: religious, older, least outside reading.

NPS Students: older, lower income, higher need for measurement.

<u>Group 4</u> (Positive attitude, highest knowledge)

HS Students: youngest, higher income and need for measurement.

Educators: older, higher income, highest need for measurement.

Business: most educated, youngest.

NPS Students: younger, no religious preference, highest need for measurement.

Group 5 (Negative attitude, lower knowledge)

HS Students: older, low income and need for measurement.

Educators: younger, less outside reading.

Business: older, less educated.

NPS Students: low need for measurement, older.

Group 6 (Negative attitude, higher knowledge)

HS Students: lowest need for measurement, younger.

Educators: older, least outside reading.

Business: younger, less educated, no religious preference.

NPS Students: younger, religious, higher income.

It must be noted that these are but predictors. However, it is posited that these characteristics can be used to identify subpopulations of interest and to place these groups into a priority of effort expended for maximum adoption.

2. Types of Learning Involved

The metric system has a consistent naming scheme (using a set of prefixes) geared with decimal hierarchy of units related to each of the six base-units or to the derived units. The whole coherent, rational and simple system can be summarized in Figure 6-1.

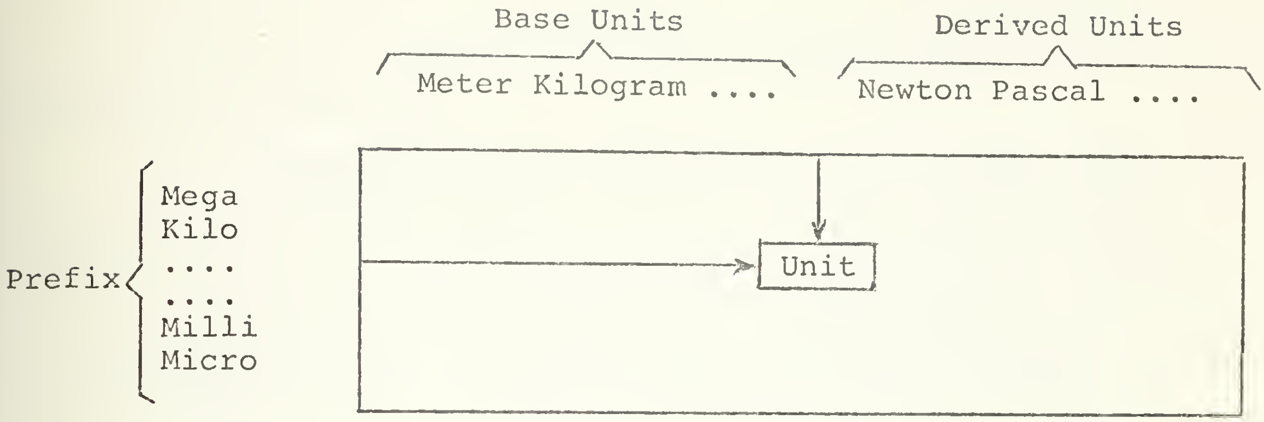

Fig. 6-1 The Metric System Naming Scheme

Using the insights from Gagné the following items should be noted:

a. Verbal associations: In the act of measurement and weighing, verbal associations are necessary in memorizing the size of each unit.

b. Linking of verbal associations: In order to group verbal associations into the same column, linking is an intermediate but necessary level of learning.

c. Chaining: The ability to group linkages will enable the learner to discriminate between rows or columns.

d. Multiple discriminations: In order to discriminate among prefixes and base units or derived units the learner must be able to make use of groups of previously leanred chainings.

e. Principle and concept learning: It is felt that these levels of learning in measurement (i.e. mastering

of the ideas of length, volume, mass, etc...) will probably have been reached during the learning of our traditional measurement procedures.

f. Problem Solving: According to Gagné this level of learning requires mastering of each of the previous levels and will, of course, be evidenced only by the ability to successfully measure using metric base units and derived units.

All six of these levels of learning must be included in a training strategy and must be ordered in such a way that a particular level of learning will follow upon previously mastered prerequisites.

Managers will, of course, establish their own priorities for which subgroup needs the greater amount of technical training. Less intense training may be in order for the remainder who are less involved with measurement activities.

Reinforcement of these particular learning levels may be achieved by providing reading materials to those already identified as active readers, providing financial incentives where noted it will probably be of more importance.

3. Use of Change Agents and Their Assistants

As change agents and their assistants, together with opinion leaders, play an important role in the diffusion and adoption of innovations, they should be used to the full extent in the two-step or multistep flow of new ideas from sources to the followers [Ref. 23, Pp. 208-247]. If the

change agents are themselves opinion leaders, they can act uniquely and directly as a link between outside sources of information and the followers in the organization. If they are not, it would be better for them to work through opinion leaders. In an innovation-resisting organization, change agents might have first to gain support from top management as well as from outside and inside sources.

Although the "right time" (crisis) would come when the U.S. Congress promulgated a national program for metric conversion, change agents might accelerate the adoption by generating more perceived crises in the organization.

Change agents should convince the followers, or at least the opinion leaders, of the need and advantages of the changeover, and the disadvantages of not going metric or changing too slowly (keeping in pace with others, competition, more cost, ...). They should help the planners to minimize the cost of the change which is one of the most important obstacles (financial initially but psychological by consequence).

The role of change agents in each stage of the adoption process will be described in the next subsection.

4. <u>Actions To Be Taken In Each Stage</u>

a. Awareness Stage

Appropriate mass media should be used to facilitate the flow of information from outside sources into the organization. The tactics of "abundance" might be useful in

gaining attention of the followers. Change agents can help in selecting and using mass media, in finding appropriate external sources of information.

b. Interest stage

As the individual becomes interested in the metric system, and seeks additional information about it, adequate means should be provided to him to reach this goal. Booklets, magazines and other documents about the metric system might find their use here.

c. Evaluation stage

While the individual weighs the advantages and disadvantages of adopting the metric system, the internal change agents, their assistants and other opinion leaders play a most important role as localite and personal (face-to-face) information sources. Here the simplicity, rationality and coherence of the metric system should be stressed.

d. Trial stage

The trial usually is a test on a small scale. Divisibility is an important characteristic that influences the adoption. The metric system is a quite coherent one and its mastering can be divided into separate components. Change agents and their assistants should assist by designing trials which take advantage of the divisibility of these adoptions.

e. Adoption stage

Even with success on a smaller scale, the guidance of change agents is still needed for full scale adoption.

Their effort should help the followers to continue the adoption. Reward schedules are most important at this stage to maintain the learning achieved. Intrinsic rewards of the simplicity of the metric system should be highlighted. Accelerated promotion and other tangible, extrinsic rewards should also be considered.

It is felt that the above observations will assist organizations in assigning priorities to educational efforts, selecting change agents and designing training strategies for the speedier adoption of the metric system.

C. NEED FOR FURTHER RESEARCH

1. Like any model, the above is just a simplification of the real world, based on limited data and theories. In order to check and improve its validity, the model should be tested against a control organization. Feedback would help to streamline the model during its application.

2. In this study, attitude and knowledge have been considered as two most important factors in the adoption process of the metric system. Their relationship was found to be relatively strong and was assumed to be a causal effect in which knowledge seemed to determine attitude. It is of interest to search for its real nature and to justify this assumption.

3. Like most organizations in the U.S., none of the organizations selected for this survey has adopted the metric

system. Adoption has been therefore estimated by attitude. This might influence the results of the study. As a national program for metric conversion will be promulgated soon, more adoption will be expected among the organizations. Data on the <u>rate</u> of adoption might then be available and should be used to measure the speed of adoption. This would contribute to the validity and reliability of the model.

4. Cost effectiveness study of programmatic versus "natural" adoption program has been done at the national level. It needs also to be done at the organizational level. As there have been some indications that the metric conversion in the U.S. would be implemented on voluntary compliance, many organizations might choose the "natural" way to go metric without considering cost effectiveness.

5. Finally the distribution of respondents in the survey was somewhat unbalanced. The small number of respondents from the private sector might distort the result and would not reflect what we desired to know about this sector. In order to give the model a broader spectrum of application, more surveys in the industrial and business sector is recommended.

APPENDIX A

RULES FOR THE USE OF THE SI METRIC UNITS

ISO Recommendation	R 1000	February 1969

(Annex Omitted)

RULES FOR THE USE OF UNITS
OF THE INTERNATIONAL SYSTEM OF UNITS
AND A SELECTION
OF THE DECIMAL MULTIPLES AND SUB-MULTIPLES
OF THE SI UNITS

1. SCOPE

This ISO Recommendation gives rules for the use of units of the International System of Units and for forming and selecting decimal multiples and sub-multiples of the SI units for application in the various fields of technology.

2. GENERAL

2.1 The name Système International d'Unités (International System of Units), with the abbreviation SI, was adopted by the 11th Conférence Générale des Poids et Mesures in 1960.

The coherent units are designated "SI units".

2.2 The International System of Units is based on the following six base-units.

metre (m)	ampere (A)
kilogramme (kg)	kelvin (K)
second (s)	candela (cd)

as units for the base-quantities: length, mass, time, electric current, thermodynamic temperature, and luminous intensity.

2.3 The SI units for plane angle and solid angle, the radian (rad) and the steradian (sr) respectively, are called supplementary units in the International System of Units.

2.4 The expressions for the derived SI units are stated in terms of base-units; for example, the SI unit for velocity is metre per second (m/s).
For some of the derived SI units special names and symbols exist; those approved by the Conférence Générale des Poids et Mesures are listed below:

Quantity	Name of SI Unit	Symbol	Expressed in terms of basic or derived SI unit
frequence	hertz	Hz	$1\ Hz = 1\ s^{-1}$
force	newton	N	$1\ N = 1\ kg\text{-}m/s^2$
work, energy, quantity of heat	joule	J	1 J = 1 N-m

Quantity	Name of SI Unit	Symbol	Expressed in terms of basic or derived SI unit
power	watt	W	1 W = 1 J/s
quantity of electricity	coulomb	C	1 C = 1 A-s
electric potential, potential difference, tension, electromotive force	volt	V	1 V = 1 W/A
electric capacitance	farad	F	1 F = 1 A-s/V
electric resistance	ohm	Ω	1 Ω = 1 V/A
flux of magnetic induction, magnetic flux	weber	Wb	1 Wb = 1 V-s
magnetic flux density, magnetic induction	tesla	T	1 T = 1 Wb/m^2
inductance	henry	H	1 H = 1 V-s/A
luminous flux	lumen	lm	1 lm = 1 cd-sr
illumination	lux	lx	1 lx = 1 lm/m^2

It may sometimes be advantageous to express derived units in terms of other derived units having special names; for example, the SI unit of electric dipole moment (A-s-m) is usually expressed as C-m.

2.5 Decimal multiples and sub-multiples of the SI units are formed by means of the prefixes given below:

Factor by which the unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

The symbol of prefix is considered to be combined with the unit symbol to which it is directly attached, forming with it a new unit symbol which can be raised to a positive or negative power and which can be combined with other unit symbols for compound units.

3. RULES FOR THE USE OF SI UNITS AND THEIR DECIMAL MULTIPLES AND SUB-MULTIPLES

3.1 The SI units are preferred, but it will not be practical to limit usage to these; in addition, therefore, their decimal multiples and sub-multiples, formed by using the prefixes, are required.

In order to avoid errors in calculations it is essential to use coherent units. Therefore, it is strongly recommended that in calculations only SI units themselves be used, and not their decimal multiples and sub-multiples.

3.2 The use of prefixes representing 10 raised to a power which is a multiple of 3 is especially recommended.

NOTE. – In certain cases, to ensure convenience in the use of units, this recommendation cannot be followed; column 5 of the tables in the Annex gives examples of these exceptions.

3.3 It is recommended that only one prefix be used in forming the decimal multiples or sub-multiples of a derived SI unit, and that this prefix be attached to a unit in the numerator.

NOTE. – In certain cases convenience in the use requires attachment of a prefix to both the numerator and the denominator at the same time, and sometimes only to the denominator. Column 5 of the tables in the Annex gives examples of these exceptions.

4. NUMERICAL VALUES

4.1 When expressing a quantity by a numerical value and a certain unit it has been found suitable in most applications to use units resulting in numerical values between 0.1 and 1000.

The units which are decimal multiples and sub-multiples of the SI units should therefore be chosen to provide values in this range; for example,

observed or calculated values	can be expressed as
12000 N	12 kN
0.00394 m	3.94 mm
14010 N/m^2	14.01 kN/m^2
0.0003 s	0.3 ms

4.2 The rule according to clause 4.1 cannot, however, be consistently applied. In one and the same context the numerical values expressed in a certain unit can extend over a considerable range; this applies especially to tabulated numerical values. In such cases it is often appropriate to use the same unit, even when this means exceeding the preferred value range 0.1 to 1000.

4.3 Rules for writing symbols for units are given in ISO Recommendation R 31 : General principles

concerning quantities, units and symbols.

5. LIST OF UNITS

For a number of commonly used quantities, examples of decimal multiples and sub-multiples of SI units, as well as of some other units which may be used, are given in the Annex to this document.

(ANNEX OMITTED)

APPENDIX B

FORM OF THE QUESTIONNAIRE

METRIC SYSTEM SURVEY

1. Your age: _____.   2. Sex: _______.

3. What was the last grade you completed in school? _______

4. What is your job, position, field of activity, rank, service, curriculum, grade, ...? ______________________

5. Please mark on the scale according to the yearly income of your family:

____	Under $3000	_____	$7000 to $9999
____	$3000 to $4999	_____	$10,000 to $14,000
____	$5000 to $6999	_____	$15,000 and over.

6. What is your religious preference? ______________

7. How many magazines do you subscribe to regularly? ______

8. To how many education programs do you listen on TV each week? _____________

9. How often do you travel?

	Never	Sometimes	Often
- out of town	_____	_________	_____
- out of state	_____	_________	_____
- out of country	_____	_________	_____

10. How often do you measure things? (in your job and at home)

____ Never, ____ Sometimes, _____ Often.

11. How often do you have meals or parties with:

- (for Managers or Educators) your subordinates or students?
- (for Workers or Students) your boss or teacher?

_____ Never, _____ Sometimes, _____ Often.

12. How do you feel about the adoption of the metric system?

Strongly against	Moderately against	Neutral	Moderately for	Strongly for
____	____	____	____	____

13. Please explain why you feel as you do about the adoption of the metric system? ______________________________

____

____

14. The percentage of countries in the World that have converted to the metric system is:

_____ Less than 50% _____ 70 to 89%

_____ 50 to 69% _____ 90% or more.

15. Please state in:

	U.S. Customary System	Metric System
- your height	___ ft. ___ ins.	____ cm.
- your weight	______ lbs.	____ kg.

16. One ounce is equivalent to:

_____ 0.45 gram _____ 20 grams

_____ 12 grams _____ 28 grams.

17. Pure water freezes at _____ degrees C.

18. How many liters are there in 286.30 hectoliters?

_________ liters.

19. How many square meters are there in 7,345.80 dm^2?

_______________ m^2.

20. Please fill in the following table which is used to form decimal multiples and sub-multiples in the metric system:

Prefix	Factor by which the unit is multiplied	Symbol
Kilo	1,000	k
Hecto	_____	___
_____	0.01	___

21. How often do you handle metric equipment?

_____ Never, _____ Sometimes, _____ Often.

22. Do you think in metric units?

_____ Never, _____ Sometimes, _____ Often.

23. To be familiar with the metric system, do you think training is needed:

	None or little	Some	Great Deal	Don't know
- for you?	____	___	___	___
- for your school or company?	____	___	___	___

24. What do you predict will be the most important obstacles to conversion to the metric system? ____________________

____

APPENDIX C

CODING OF THE DATA

(1) Age: Age of the respondent.

(2) Sex: Sex of the respondent (female: 1, male: 2).

(3) Education: Last year completed in school.

(4) Occupation: Occupation of the respondent (high school student: 1, high school teacher: 2, worker: 3, manager: 4, professor: 5, NPS student: 6).

(5) Income: Annual family income of the respondent (under $3,000: 1, $3,000 to $4,999: 2, ..., $15,000 and over: 6).

(6) Religion: Religious preference of the respondent (protestant: 1, catholic: 2, other: 3, no preference: 4). (This coding was used for describing the profile of the population; later it was changed to be used for analysis as follows: any religious preference: 1, no preference: 2).

(7) Reading: Number of magazines regularly subscribed to by the respondent plus one.

(8) TV program: Number of education programs watched on TV each week by the respondent plus one.

(9) Traveling: Coded according to the frequency (never, sometimes, often) and distance (out of town, state, country) at which the respondent usually traveled (lowest: 1, highest: 5).

(10) Measurement need: Frequency with which the respondent usually measured things (never: 1, sometimes: 2, often: 3).

(11) Social relations: Frequency with which the respondent usually had meals or parties with his subordinates or superiors (coded same as measurement need).

(12) Attitude: Attitude of the respondent toward the adoption of the metric system (strongly against: 1, mildly against: 2, neutral: 3, mildly for: 4, strongly for: 5).

(14) to (22): Knowledge of the metric system (questions 14, 16, 17, 18, and 19: coded from 1 (lowest) to 4 (highest); question 15: from 2 to 8; question 20: from 1 to 8; questions 21 and 22: from 1 to 3; these scores were added up to give the total score for the knowledge of the metric system, coded from 10 to 42).

(23) Training need: Need of training to use the metric system for the respondent and for his organization as perceived by the respondent (lowest: 1, highest: 3).

Missing values: all missing values are coded zero.

APPENDIX D

FACTOR ANALYSIS

VARIMAX Rotated Factor Matrices

Table D-1 High School Students

	Factor I	Factor II	Factor III
Education	0.72109	-0.04309	0.37812
Income	0.57598	0.03035	-0.06529
Religious Preference	0.12782	-0.01346	0.43965
Reading	0.14081	-0.38881	-0.35785
T.V. Program	-0.05778	0.40864	-0.14386
Traveling	0.48353	0.00280	-0.06452
Measurement need	0.12402	0.67433	0.04129
Social relation	-0.01351	0.25861	0.07929

Table D-2 Educators

	Factor I	Factor II	Factor III	Factor IV
Education	0.89026	0.02910	-0.19223	0.40270
Income	0.61717	0.02919	0.12295	0.12607
Religious Preference	0.10523	0.28023	-0.01693	0.21217
Reading	0.03899	-0.05629	0.12529	0.58430
T.V. Program	-0.66817	0.07051	-0.02283	0.18703
Traveling	0.04229	-0.04013	0.87078	0.14075
Measurement Need	-0.01063	0.36960	-0.12159	-0.03608
Social Relation	-0.13039	0.95672	0.21673	-0.10492

Table D-3 Business

	Factor I	Factor II	Factor III
Education	0.69609	0.30698	0.04010
Income	0.42367	0.10278	0.05225
Religious Preference	-0.28313	0.25502	0.71776
Reading	0.68797	-0.03831	-0.10189
T.V. Program	0.07222	0.35014	0.22209
Traveling	0.28239	-0.15309	0.25304
Measurement Need	0.09096	-0.01937	0.45175
Social Relation	0.10374	0.88299	-0.10458

Table D-4 NPS Student

	Factor I	Factor II	Factor III
Education	0.13699	0.11374	0.14641
Income	0.01949	0.22469	0.15783
Religious Preference	-0.03440	-0.07242	-0.51121
Reading	0.10653	0.61922	0.18094
T.V. Program	0.17243	0.11831	0.05355
Traveling	0.11597	0.17793	-0.01603
Measurement Need	0.34487	0.17607	-0.02665
Social Relation	0.72387	-0.03952	0.13080

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